POWER

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The Steam Engine 100 Years Ago

IN 1827 John Farey, Engineer, published in London a "Treatise on the Steam Engine."

Even at that time there seems to have been an appreciation of the social-economical importance of power, limited as was its use in proportion to what a century of further development has wrought.

Up to 1800 Boulton and Watt had made at Soho only 46 engines aggregating 648 rated horsepower.

In 1804 and 1805 Mr. Farey visited all the establishments in which steam power was used in and about London to obtain drawings and dimensions of the engines and particulars of their performance. These studies formed his entire occupation during that period, and he believed that the accompanying list comprised all the engines that were then in use in London.

At the time of the issue of his book, a century ago, there were in London about 290 engines aggregating 5,460 horsepower, in Manchester about 240 of 4,760 horsepower, in Leeds about 130 of 2,330 horsepower, in Glasgow 80 or 90 and in Birmingham, Sheffield and the smaller towns of Lancashire and Yorkshire numerous steam mills many of them "on an extensive scale."

And with even this meager background he writes:

"The productiveness of labour has been so greatly increased by this gigantic auxiliary and by the improved system of manufactures and commerce to which it has given birth that those conveniences of life and attributes of wealth which were formerly considered to be one of the distinctions of the first classes of the community are now acknowledged to belong equally to that middle class which may be said to consist of labourers who apply their minds to useful industry, instead of their hands."

	Number of Engines	Aggregate Horsepower
Public water works	10	270
Docks for shipping	6	150
Temporary public works	7	68
Public baths	2	8
Total power for pumping water	25	496
Breweries	17	250
Distilleries	8	114
Vinegar makers	3	20
Dye houses	8	80
Woolen cloth dresser	1	24
Tanneries	2	8
Cotton mills	2	12
Callenders and packers	2	22
Calico printers	4	20
Sail-cloth weaving	1	14
Flour mills	6	52
Oil mills	3	20
Mustard mills	2	12
Drug mills	3	28
Paper mills	2	20
Colour makers	3	26
Starch maker	1	10
Roperies	3	24
Iron forge	1	40
Foundries and machine makers	10	42
Cutlers	2	3
Glass cutter	1	6
Diamond cutter	1	4
Silversmiths	1	8
Totals	112	1355

Kip's Bay Plant of the New York Steam Corporation

WITH an installed capacity of one million pounds of steam per hour this new station will supply steam for heat and power in the uptown district. Eventually, it will contain 12 units with a total capacity of four million pounds of steam per hour. Owing to high land values the plant is designed to give high capacity per square foot of floor area. Boiler, economizer and air heater comprise a single unit with a total surface of 71,682 sq. ft. Steam is generated at 275 lb. and and discharged through reducing valves to distribution system at 150 lb. The guarantee efficiency of each unit is 88 per cent at 325,000 lb. of steam per hour.

LOCATED on the block extending from First Avenue to the East River at Thirty-fifth Street, is the new steam generating plant of the New York Steam Corporation known as the Kip's Bay Station. The territory served by this company with steam for both power and heating purposes consists of two distinct districts rather widely separated and not physically connected. The downtown area lies between Duane Street and Battery Park and comprises the city's financial district. The uptown area extends from Twenty-eighth Street to Eighty-first Street, and is in an important commercial and residential section.

Owing to the rapid growth and development in the uptown area, the company laid plans in 1925 for a new plant to supplement the capacities of the two existing plants located at Fifty-ninth Street and the East River. Although these two plants have a combined capacity of nearly one million pounds of steam per hour, the company found it necessary two years ago to arrange for the purchase of additional steam from the New York Edison Company's Water Side Stations to give the necessary reserve until the new Kip's Bay Station could be finished.

As previously intimated, the new plant is designed to contain eventually twelve steam generating units with a total capacity of over four million pounds of steam per hour. The first unit was first fired on Dec. 23, 1926, and since that time two similar units have been erected. A fourth unit is now on order and is required to be ready for operation by the late fall of this year, thus giving the first section of the plant a capacity of approximately one and a half million pounds of steam per hour. Owing to an unexpected increase in the demand for steam during the latter part of 1925 and early part of 1926, it was necessary to rush the construction work as rapidly as possible; it was also necessary to place the first unit into preliminary operation under extremely difficult operating conditions. Primarily, the new station is a heating plant. Steam is generated at 275 lb. gage and passed through reducing valves to the distribution system. The pressure on the system varies between 120 and 180 lb., depending on the amount of steam transmitted. Although the plans call for a total of five 3,000-kw. generating units, two of which are already installed, the current generated will be used exclusively to drive the auxiliaries and no current will be sold.

The decision to use pulverized coal as the method of firing the boilers in the new plant was reached after a prolonged study of plants using this method. In addition to greater flexibility of operation, ease of control and reduction of banking losses, the possibility of almost completely inclosing the furnace and boiler with water-cooled wall to exclude refractory troubles and the ability to burn various grades of coal with equal efficiency were influencing factors.

Referring to the cross-sectional elevation, Fig. 2, and the view of the boiler in course of erection, Fig. 4, the construction and arrangement of the various parts comprising the complete unit will be readily understood. The boiler is a six-drum unit with the two main steaming sections placed vertically on 19-ft. 2-in. centers. The top drum is a dry drum connected by bent tubes to the two upper drums, but isolated from the path of the gases. The lowest drum forms the mud drum and is connected through the floor screen to the vertical front water walls of the furnace. In the design of these units water-cooled

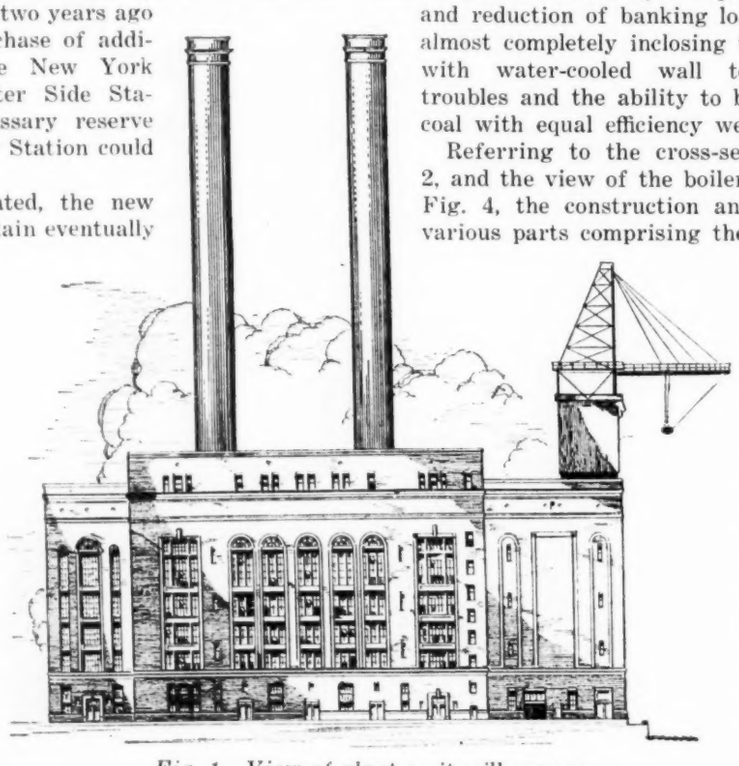


Fig. 1—View of plant as it will appear when completed

	Heating Surface, Sq.Ft.
Floor screen	688
Furnace front wall	942
Burner arch	500
Furnace side wall	1,336
Boiler side wall	666
Boiler	10,670
Economizer (two)	10,080
Air heater (two)	46,800
Total surface	71,682

	Expected Temperature, Deg. F.
Gas leaving boiler	1,270
Gas leaving economizer	692
Gas leaving air heater	291
Air entering air heater	60
Air leaving air heater	527
Water entering economizer	200
Water leaving economizer	344

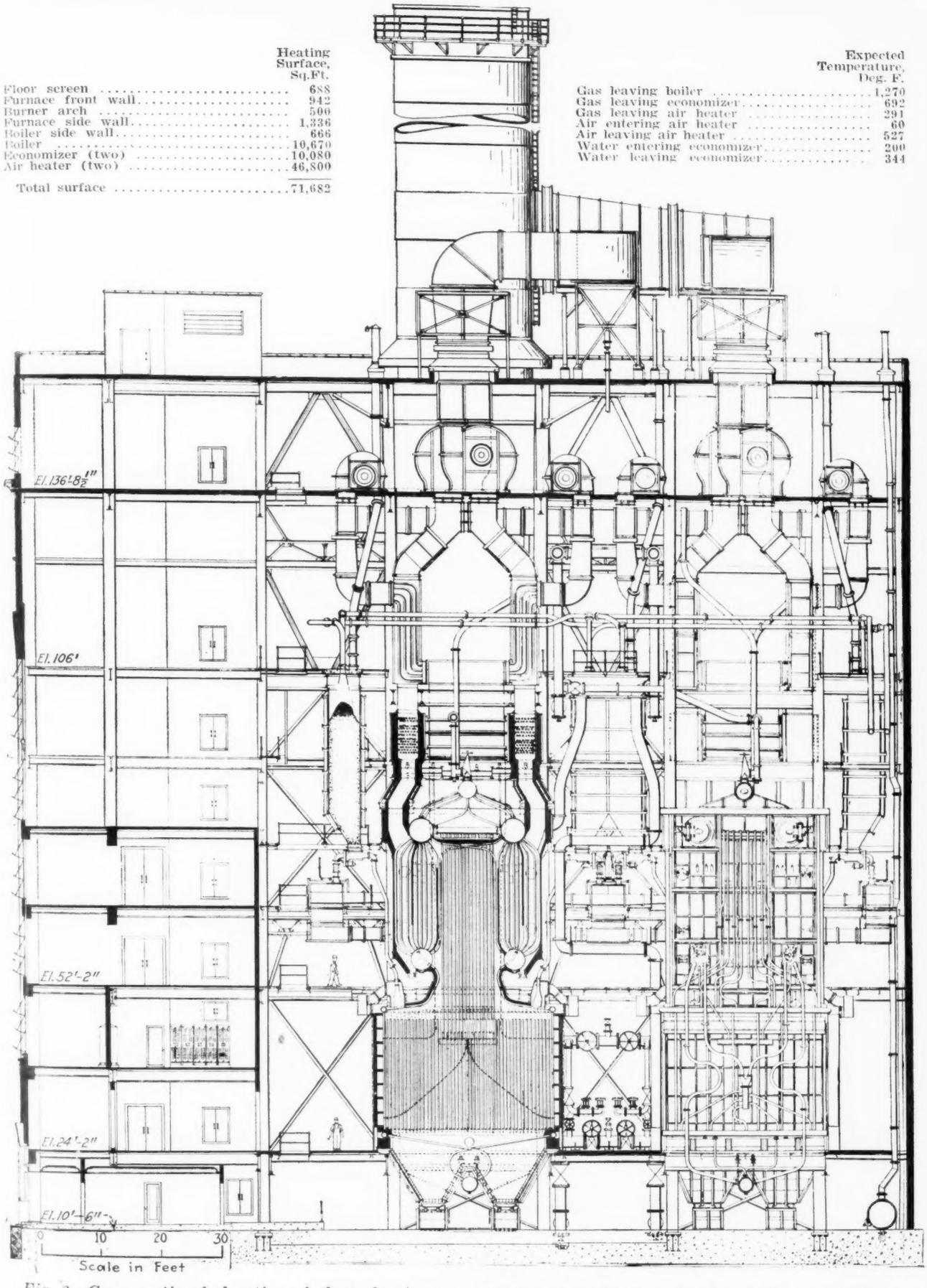


Fig. 2—Cross-sectional elevation of plant showing arrangement of combustion chamber, boiler, economizers, air heaters, primary and induced-draft fans

walls have been utilized to replace refractories to a much greater extent than ever attempted before. Not only is the complete combustion chamber water-cooled with bare fin tubes, but the cooling surface is extended up the two sides of the boiler to the center line of the upper steam and water drums. Fin tubes have also been used in the outer row of each of the vertical steaming sections. In this way the use of refractory has been reduced to a minimum.

Each of the four side walls of the combustion chamber, as well as the two side walls of the boiler, has independent headers top and bottom, with independent connections to the boiler drums. The upper header of the front walls connects with the lower drum of the boiler through the arch tubes. These tubes are so spaced that the tile in back of the fins is exposed to the fire, thus tending to increase the radiation to the flame at this point. The arch tubes do not discharge into the lower drum, but are connected by through tubes so that the steam generated in the floor screen, front-wall tubes and arch tubes, is carried to the upper steam and water drums of the boiler. The connections to the upper and lower headers of the side walls of the combustion chamber are clearly shown on the exterior view of the boiler, Fig. 2.

The furnace volume is approximately 19,000 cu. ft., which, at the expected average rating of the boiler, will make an energy liberation of approximately 22,000 B.t.u. per cubic foot of volume.

Contrary to what has become more or less general practice, both economizers and air preheaters have been installed. From extended experience with economizers in the other stations operated by the company, it was found that economizers had the effect of flattening the efficiency rating curve so that when the station was operated at maximum rating there was no appreciable falling off in efficiency. Also, owing to the high land values it appeared advisable to limit the size of the boiler and put the additional surface in an economizer placed in an independent setting above the boiler. In this way the steam produced per square foot of floor area could be materially increased.

As to the advantage of air preheaters a preliminary survey of the results obtained in plants already equipped with air heaters indicated that a high air temperature has an advantage in overcoming the tendency to smoke with high-volatile coals and also that it was advantageous to use air heaters to raise the efficiency and reduce the exit gas temperature to as low a figure as the metal temperatures and dewpoint would permit, particularly under base-load conditions such as will obtain at Kip's Bay.

Referring again to Fig. 2, it will be seen that the combustion chamber, boiler, economizers, air heater and induced-draft fans are directly in line, vertically, with the economizer, air heater and fans in two units per boiler. The fans discharge through cinder catchers into the breeching leading to the stack. The ducts between the air heaters and the fans

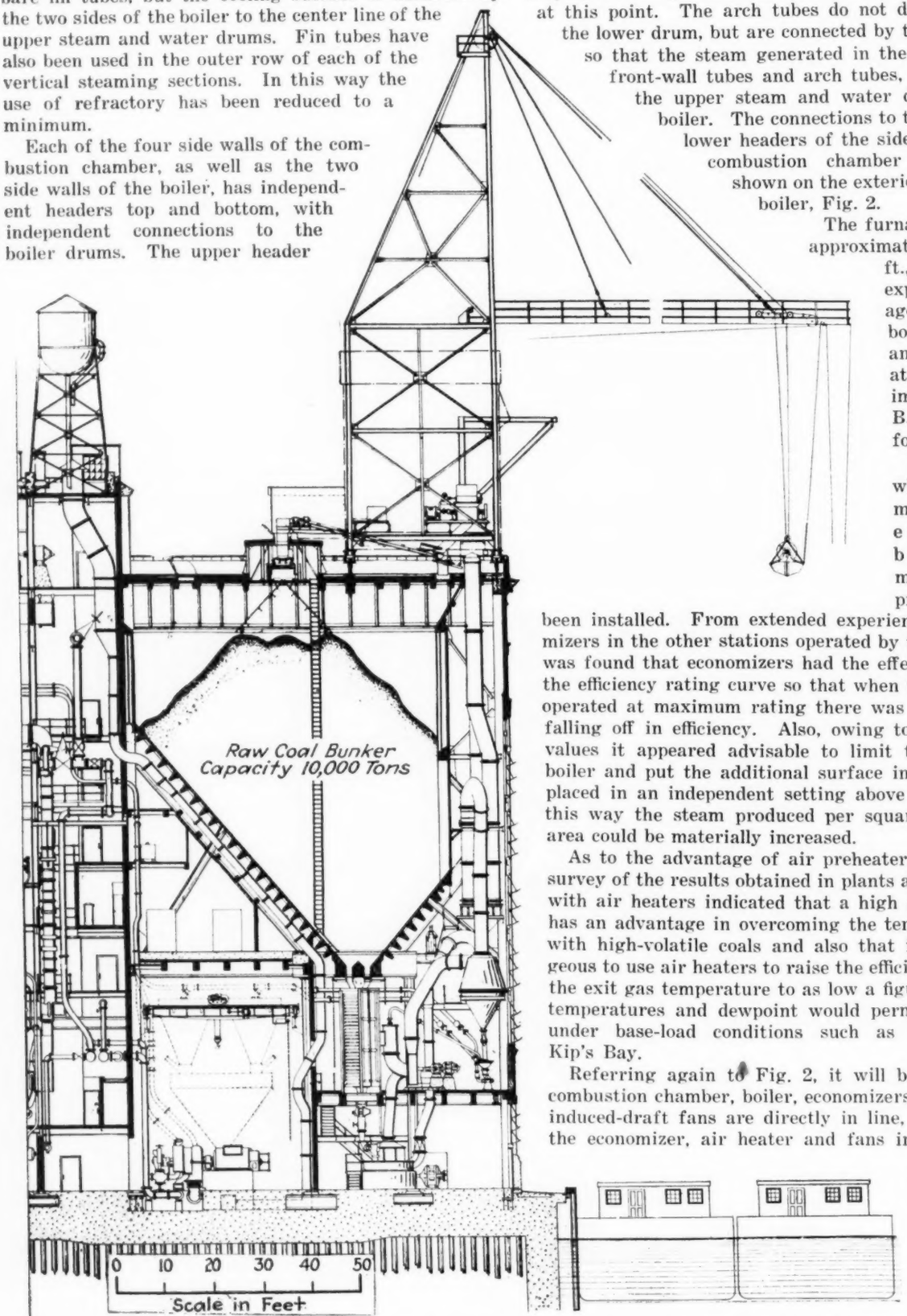


Fig. 3—Section showing arrangement of raw-coal handling equipment, preparation plant and turbine room

are so dampered that either fan can be operated separately or both in parallel. All the fans in the plant are on one floor and are subject to remote electrical control from the main boiler plant by means of motor-operated drum controllers.

Fig. 3 shows a section through the coal handling and preparation plant. The coal is unloaded directly from barges by means of a traveling coal tower to a raw-coal bunker of 10,000 tons capacity. The boom of the tower is of sufficient length to permit unloading two barges placed side by side at the dock. In the tower the coal passes through a crusher and over a weighometer belt and magnetic pulley before being discharged to the bunker. In addition to the weighometer just mentioned, a system of weighing hoppers has been installed for weighing the coal in pulverized form. This equipment is indicated by dotted lines in Fig. 3.

From the main bunker the coal passes through vertical rotary steam-heated driers directly to the pulverizing mill feeders. Four 15-ton-per-hour air-separation-type pulverizers comprise the initial mill installation.

From the cyclone separators, to which the coal is delivered from the mills, it passes directly to the transporters and is conveyed through 10-in. pipe lines to the fuel bins adjacent to the boilers or to the weighing bins previously mentioned. To preclude the possibility of any dust from the preparation plant reaching the atmosphere, all vents lead through an air washer.

All motors used for driving the coal handling and preparation equipment are electrically interlocked for sequence starting and stopping. In the preparation plant a master gage on the compressed-air receiver, from which the air used to aërate the coal in the transport line is drawn, forms the master control for the entire equipment. With reference to the other machines in the plant, the stopping of any particular unit will affect only the units ahead of it in relation to the direction of coal flow, but not beyond.

Each boiler is fired by twelve forced-draft burners, six on each side, placed vertically in the arch forming the top of the combustion chamber. The feeders, of which there is one for each burner, are independently driven by direct-connected motors. Each motor is equipped with a field rheostat and a motor-operated gang rheostat, the elements of which are in series with the armature circuits. This arrangement provides for individual feeder speed adjustment as well as quick load adjustment.

The secondary air for combustion is supplied by two forced-draft fans for each boiler. The fans discharge against a static pressure of 6.3 in. of water through the air heaters and branch ducts to the hollow front walls of the furnace, where the air enters the combustion chamber through openings cut in the fins of the water-cooled walls. The primary air is drawn from the main preheated air duct by any one of four fans and discharged at a pressure of 16 in. of water to a common primary air duct and thence to the coal feeder. The primary air is tempered with boiler-room air at the fan inlet and the temperature reduced to from 150 to 200 deg. F. The air to the burners is taken from the main duct by a scoop connection and delivered to the burners at full temperature and about 1 in. of water pressure.

All the auxiliaries in the plant are motor-driven with the exception of the boiler-feed pumps, which are turbine-driven. Most of the constant-speed motors above 50-hp. are operated on 2,300-volt current, while all the smaller motors operate at 440 volts. Direct current for the feeder motors is furnished by motor-generator sets.

As there are no returns from the distribution system, city water is used for feed purposes. The water is taken directly from the city mains and passes to a feed-water heater where the temperature is raised to approximately 200 deg. by the exhaust steam from the generating units and feed pumps before being fed to the econ-

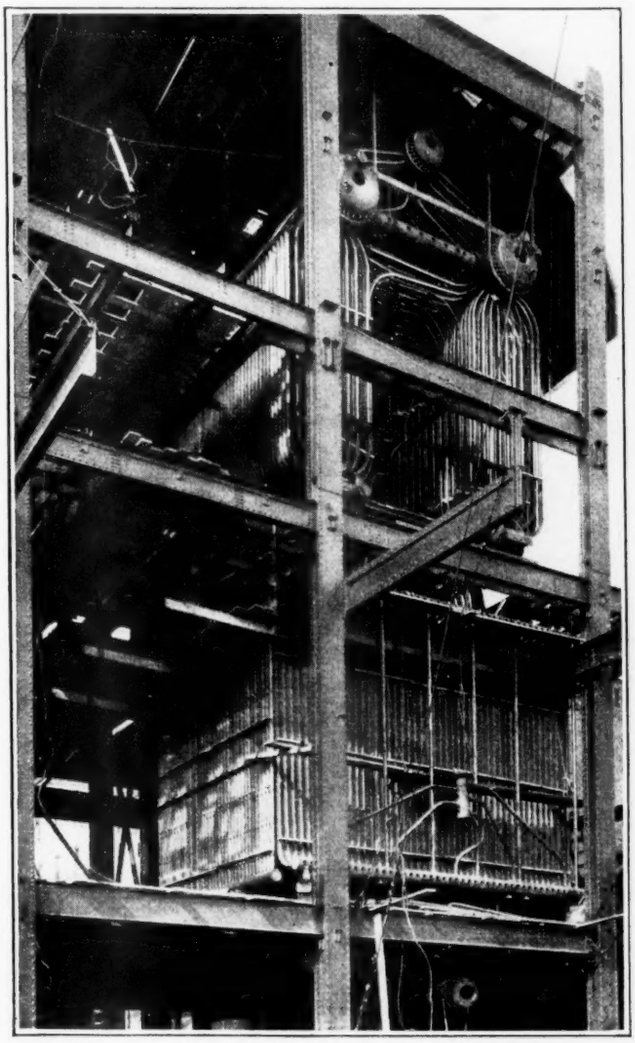


Fig. 4—View of steam generating unit in course of erection

omizers. Following the practice used in the other stations of the corporation, the treatment contemplated is the use of caustic soda with full chemical control of the sulphate ratio and concentrations.

The electrical generating units can be operated with either of two initial steam pressures and either of two back pressures, to give flexibility in the operation of the station and prevent loss of exhaust steam during the summer periods. Steam can be admitted to the turbines at 275-lb. gage and exhausted at either 150 or 5-lb. gage, or steam can be admitted through reducing valves at 150-lb. and exhausted at 5-lb. During periods of low steam demand, especially when the proportion of exhaust steam is too great to be absorbed by the feed water, one of the units will be run at high back pressure and reduced load, its exhaust being discharged directly into the distribution system.

MECHANICAL EQUIPMENT, KIP'S BAY STATION, NEW YORK STEAM CORPORATION

GENERAL

Location	35th St. and E. River, N. Y.
Service	Steam for heat and power
Capacity Present Building:	
Boiler house, lb. of steam per hr.	1,950,000
Mill house, tons of coal per hr.	105
Capacity ultimate, lb. of steam per hour	3,900,000
Floor Areas (column centers):	
Boiler room	107 ft. 6 in. x 147 ft. 10 in.
Mill room	40 ft. 6 in. x 146 ft. 6 in.
Turbine room	36 ft. 0 in. x 84 ft. 0 in.
Ashpit room	36 ft. 0 in. x 41 ft. 6 in.
Coal-weighing room	36 ft. 0 in. x 21 ft. 0 in.
Type of construction	Steel, concrete and brick
Foundations	Pile and reinforced mat
Floors	Reinforced concrete and grating

BOILERS, ECONOMIZERS AND AIR HEATERS

Boiler manufacturer	Ladd Boiler Co.
Type	5-drum 1 additional water-screen drum
Number installed	3
Heating surface, sq.ft.	10,670
Furnace volume, cu.ft. (approx.)	19,000
Boiler pressure, lb. gage	275
Economizers, two per boiler	Power Specialty Co.
Surface per boiler, sq.ft.	10,080
Ratio economizer to boiler surface	0.945
Air heaters, two per boiler	Combustion Engineering Corp.
Surface per boiler, sq.ft.	46,800
Ratio air heater to boiler surface	4.39
Soot blowers	Diamond Power Specialty Co.
Feed-water regulators (Copes)	Northern Equipment Co.
Fuel, bituminous coal	14,500 b.t.u. per lb., dry

FURNACES AND SCREENS

Water-cooled fin-tube	Combustion Engineering Corp.
Water screen surface, sq.ft.	688
Front wall surface, sq.ft.	942
Furnace side wall surface, sq.ft.	1,336
Boiler side wall surface, sq.ft.	666
Total surface, sq.ft.	3,632
Ratio screen to boiler surface	0.34

STACK AND DRAFT EQUIPMENT

Stacks	1 for six boilers
Type	Self-supporting steel
Diameter, ft	22
Height above street, ft	376
Height above burners, ft.	335
Induced-draft fans, 2 per boiler	Green Fuel Economizer Co.
Capacity each	87,500 cu.ft. per min., 12 in. static pressure
Drive	G. E., 300-hp. motor
Forced-draft fans, 2 per boiler	Green Fuel Economizer Co.
Capacity each	50,000 cu.ft. per min. 6.3 in. static pressure
Drive	G. E. 100-hp. motor
Primary-air fans, one per boiler	B. F. Sturtevant Co.
Capacity	22,200 cu.ft. per min., 16-in. static pressure
Drive	G. E. 100-hp. motor

All-fan motors, 2,300 volts, wound-rotor, remote-speed control

ASH HANDLING SYSTEM

Manufacturer	Allen-Sherman-Hoff Co.
Type	Hydrojet
Ash Gates	2 double gates per boiler
Pumps (two)	Morris Machine Works
Capacity	1,500 g.p.m., 305-ft. head, 1,750 r.p.m.
Drive	G. E. 200-hp. motor
Ash storage pit, type	Reinforced concrete in foundations
Ash storage hopper C.I. with gates	Allen-Sherman-Hoff
Ash-handling crane	Harnischfeger Corp.
Capacity	7 ton 3 cubic yard
Type and size	Four-motor 30 ft. 8 in. center to center carrying wheels

RAW COAL HANDLING EQUIPMENT

Traveling tower	Maine Electric Co.
Capacity, tons per hour	350
Lift, ft.	200
Boom, length in ft.	73.5
Bucket size and type	2½-ton, clamshell
Hoist motor, 800 hp. wound-rotor	General Electric Co.
Trolley motor, 80-hp. wound-rotor	General Electric Co.
Crusher	American Ring Pulverizer Co.
Capacity, tons per hour	350
Drive, 75-hp. squirrel cage motor	General Electric Co.
Weightometer on conveyor	Merrick Scale Co.
Shuttle-belt conveyor	Robins Conveying Belt Co.
Length, ft.	50

RAW COAL HANDLING EQUIPMENT—Continued

Raw coal bunker, type	Steel and concrete in three bays
Capacity, tons	10,000
Coal driers	Combustion Engineering Corp.
Type	Rotary, steam-heated grids
Number per mill	2
Capacity each, tons per hour	10
Drive, each	2—G. E. D.C. 7½-hp. motors, shunt-wound. Ruggles-Klingerman and G. E. control
Drier exhausters, one per mill	Green Fuel Economizer Co.
Drive	G. E. 50-hp. motor, wound-rotor, remote-speed control
Drier cyclone, one per mill	Combustion Engineering Corp.
Drier air washer, one per mill	Combustion Engineering Corp.

COAL PULVERIZING TRANSPORTING AND BURNING EQUIPMENT

Manufacturer	Combustion Engineering Corp.
Pulverizers, size and type	4 air-separation six-roller
Capacity, tons per hour	15
Drive	G. E. 200-hp. motor, wound-rotor, constant-speed
Mill exhauster, number	One per mill
Drive	G. E. 100-hp. motor
Mill cyclone, number	One per mill
Coal transporters, one per mill	Combustion Engineering Corp.
Coal valves, type	Hand-operated and electric-pneumatic operated
Bin indicators, type	Electrical
Pulverized coal weigh bins	Two, each 20-ton capacity
Pulverized coal storage hopper	One, 40-ton capacity
Scales, automatic	Merrick Scale Co.
Feeders (Lopulco)	12 per boiler
Drive, individual	G. E. ½-hp. motor, shunt-wound, remote-control through motor-operated gang-armature rheostat and hand-operated field rheostats
Burners (Lopulco)	12 per boiler
Type	Forced-draft

FEED PUMPS

Manufacturer	Worthington Pump & Mach. Corp.
Number	Two 750-g.p.m. and one 1,500 g.p.m.
Head	425 lb. water at 212 deg. F.
Drive	G. E. turbines

AIR COMPRESSORS

Manufacturer	Norwalk Air Compressor Co.
Number and type	Three, compound
Capacity, cu.ft. per min.	1,650
Drive	G. E. 350-hp. synchronous motors

GENERATORS FOR AUXILIARY POWER

Manufacturer	General Electric Co.
Number	2
Type	2,300-v., 3,000-kw., 80 per cent P. F., 60-cycle, direct-connected exciter
Steam conditions	Turbine arranged to take steam at initial pressures of 275 or 150 lb and to exhaust at 150 lb. or 5 lb.

MISCELLANEOUS

Motor-generator sets	General Electric Co.
Transformers, switchboard and switching equipment	General Electric Co.
Turbine room crane	Harnischfeger Corp.
Capacity, tons	20
Fire pump, motor driven	Worthington Pump & Mach. Corp.
Salt-water pumps, motor driven	Worthington Pump & Mach. Corp.
Roof-tank pumps, motor-driven	Worthington Pump & Mach. Corp.
Motor manufacturer	General Electric Co.
Freight elevator, 12 tons capacity	Otis Elevator Co.
Passenger elevator	Otis Elevator Co.
Temperature recorders	Foxboro Instrument Co.
Pressure recorders	Foxboro Instrument Co.
Steam meters	General Electric Co. Republic Flow Meters Co. Bailey Boiler Meter
Draft gages	Bailey Meter Co.
Pressure gages	Crosby Steam Gage & Valve Co.
Gate and check valves	Chapman Valve Mfg. Co.
Globe and check valves	Crane Co.
Steel fittings	Reading Steel Casting Co.
Feed-water heater and relief valve	Cochrane Corp.
Reducing valves	Standard Steam Specialty Co.
Telephone system (Select-o-phone)	Screw Mach. Products Co.
Insulation (piping and ducts)	Insulating Products Corp.
Stop and check valves	Foster Engineering Co.
Consulting engineer	Thomas E. Murray, Inc.
General contractor	Dwight P. Robinson & Co., Inc.

Automatic Hydro-Electric Plant Built into Dam

TWENTY-SIX miles southeast of Asheville, N. C., on the Rocky Broad River, is the site of a new automatic hydro-electric plant recently put into operation by the Chimney Rock Mountains, Inc. The dam is of the multiple-arch type 104 ft. high, forming a large storage reservoir known as Lake Lure. As can be seen on the left in Fig. 1, the plant is built in one of the arches of the dam, between two of the buttresses. There are installed one 3,500- and one 1,750-hp. unit, with space provided for another 3,500-hp. machine. This plant connects to the lines of the Blue Ridge Power Co. and may be controlled from the Turner plant of this company, six miles distant.

The operation of the plant is also governed by a float switch in the forebay. If the water level in the reservoir is at a maximum, both units will come into operation. A drop of three inches from maximum level causes the largest machine to be taken out of service automatically. Another three-inch drop in the water level causes the other unit to be taken out of service.

A reinforced-concrete intake tower extends from the upstream entrance for the waterwheels in the dam to above the surface of the reservoir. Around the upper end of this tower are the trash racks and inside is a cylindrical-type gate that can be lowered to cut the water out of the waterwheels. In Fig. 2 the gate is shown hoisted to its upper position.

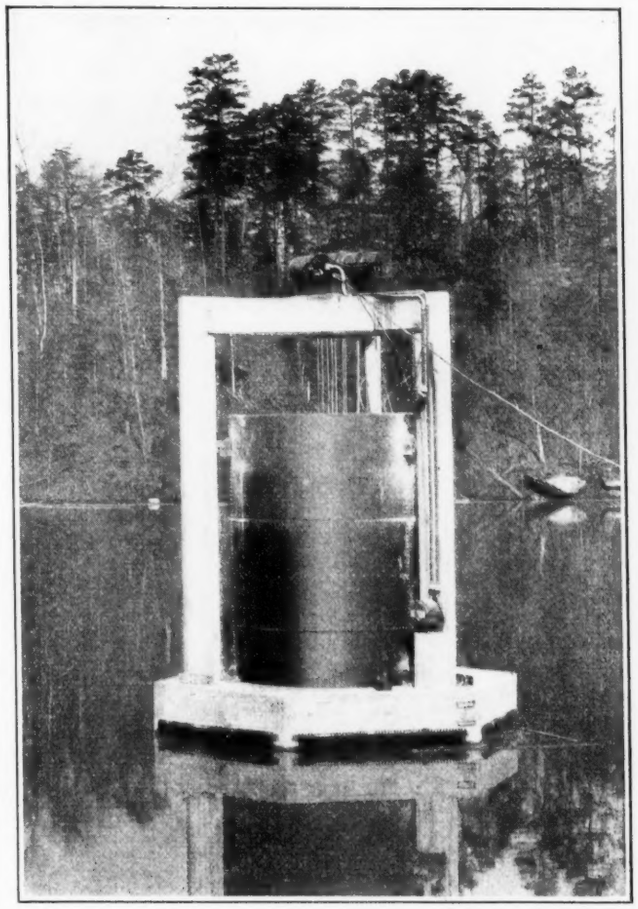


Fig. 2—Cylindrical-type gate in intake tower extending above the reservoir's surface

This gate is raised or lowered by an electric hoist, that can be controlled from the power house or from a station at the top of the dam.

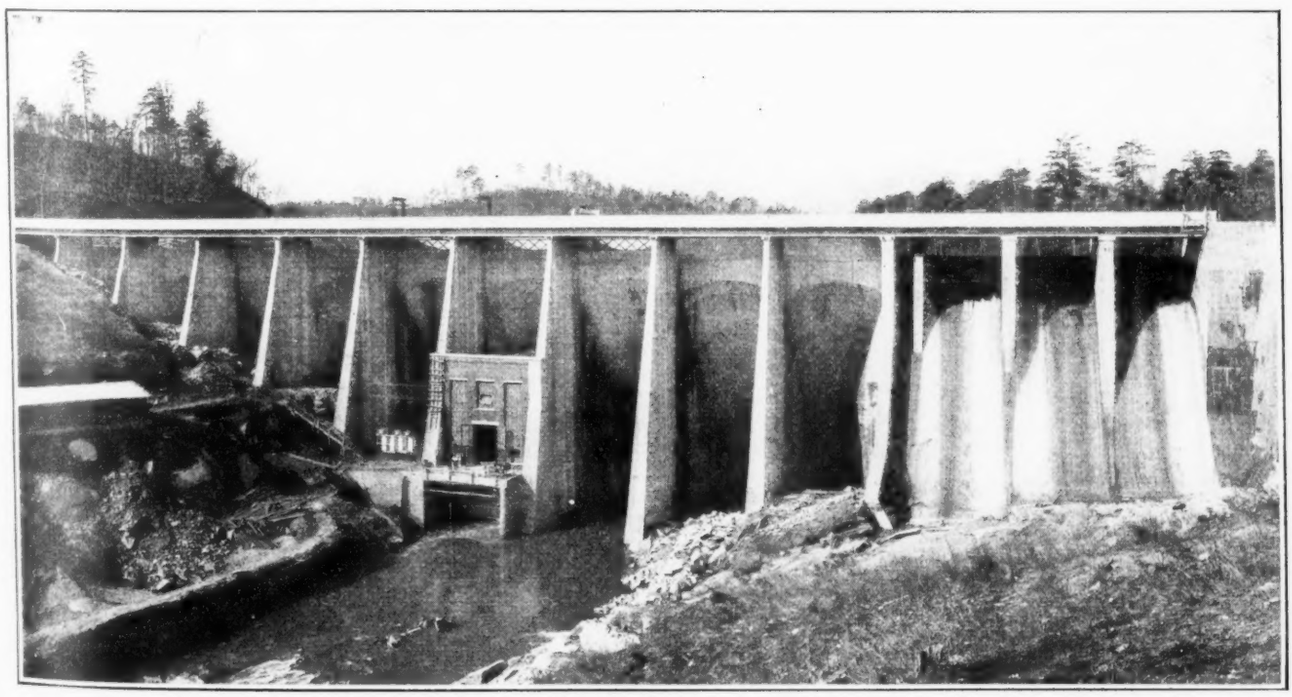
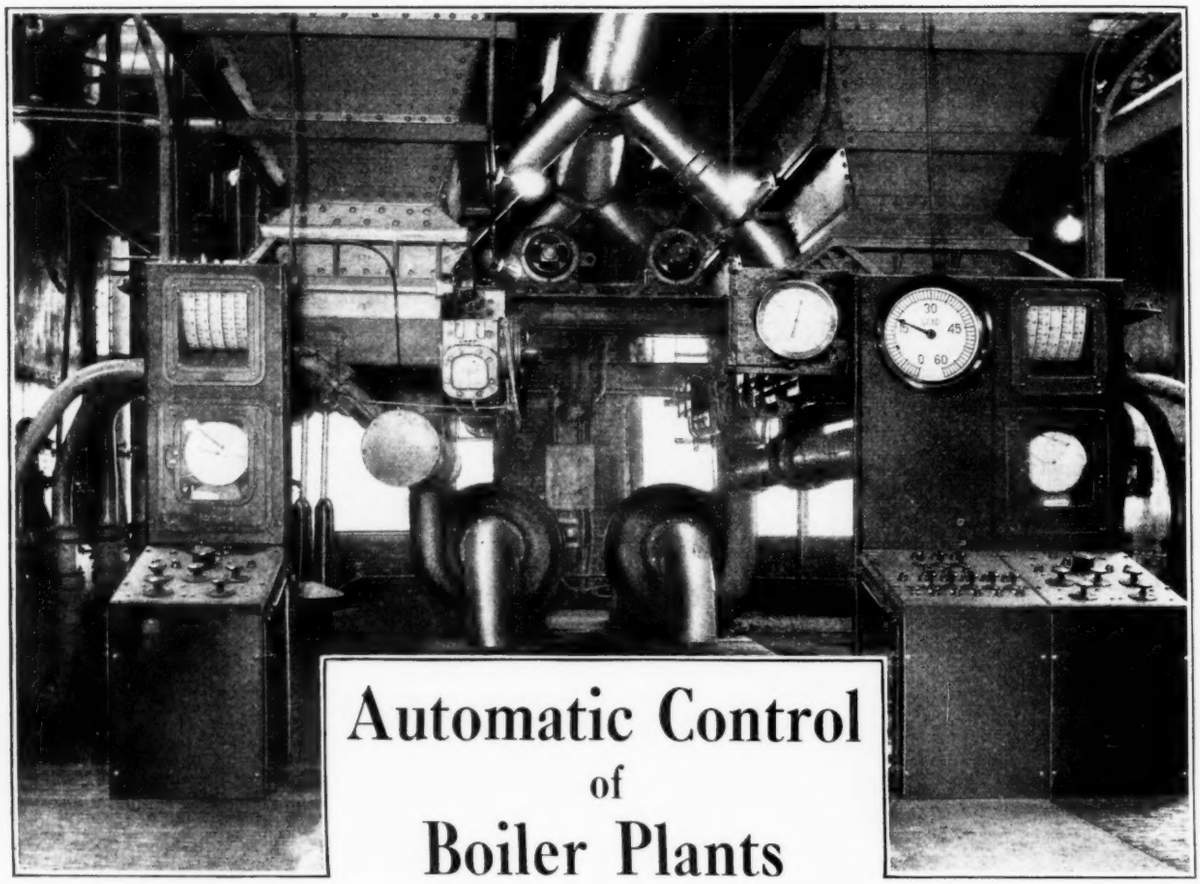


Fig. 1—Power house, shown on the left, built into one of the dam's arches, contains two units totaling 5,250-hp. capacity, with space for an additional machine



Automatic Control of Boiler Plants

BOILER-PLANT automatic control, by which all boilers in a plant may be controlled as a unit, has made rapid advances during the last few years. A brief description is given of a number of these systems

AFTER a boiler has been brought up to normal pressure, if the heat supplied to it by the combustion process is equal to the heat taken away in the steam and other ways, the steam pressure must remain practically constant. If the rate at which heat is supplied to the boiler exceeds the rate at which it is given out, then the steam pressure will rise. On the other hand, if the outgoing heat exceeds the incoming, a decrease in steam pressure will result. Therefore the steam pressure is a good index to the boiler requirements from the combustion process, and is used to give the initial impulse in practically all boiler-plant automatic-control systems.

The master controllers of the various boilers' automatic-control systems send out impulses by low-pressure air or electrically to the combustion-control equipment on the different boilers. In the Smoot Engineering Corp. system air is used, the pressure of which is controlled by the master opening or closing a leak valve, and sends pressure changes to the regulators corresponding to changes in steam pressure acting on the master. With this system the regulators for fuel feed and air flow differ only in the methods of their compensation. For a power medium to operate the regulators, oil under a pressure of about 100 lb. per sq.in. is used, although steam or compressed air may also be used.

With this system a regulator is connected to each function to be controlled, such as on the fuel feed, forced- and induced-draft fans, under-fire dampers, stack dampers and the feed pump if the pressure differential is controlled. All these regulators are connected into the master, Fig. 1, and are controlled from it. For example, if there is a slight drop in steam pressure, this will be transmitted through the master to all the regulators on the bank of boilers and the whole combustion process accelerated to meet the new demands. The compensation of the system is such that the regulators will tend to take a new position to correspond to the position of the master. However, any variation in the operation of the different boilers will also be compensated for, so that each boiler will be supplied with a volume of fuel and air corresponding to the load demands.

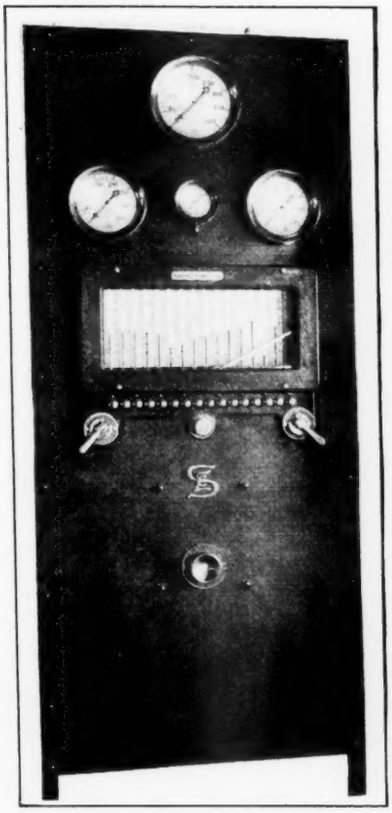
The master controller contains a corresponding number of mercury manometers, shown in the center of Fig. 1, to indicate the air pressure or loading on each regulator. By these means the fireman may observe the existing ratios between all factors under control and may adjust these to bring about any desired combus-

tion condition. The manometer scales are calibrated in inches of mercury pressure, but after all regulators have been set and adjusted, the scales may be, for convenience, calibrated in terms of the controlled factor.

On the Hagan system air is also used as the medium to transmit the changes in steam pressure acting on the master to the combustion regulators. Low-pressure air is admitted under a bell, the bottom of which is sealed in water or oil. The distance the bell is immersed in the sealing fluid is controlled by the position of the master regulator. The air pressure under the bell on the master is admitted under a similar bell on the regulators or receiving machines on the combustion equipment, so that when the bell on the master is given a new position by a change in steam pressure, the regulator bells will also take new positions.

Compressed air provides the power for operating the master regulator, Fig. 3, and receiving machines, Fig. 4. On all units the air cylinders and compensating mechanism are the same, but on the receiving machines two bells are used, one on each end of an arm balanced on a knife-edge. As previously stated, one of these bells is subjected to air pressure from the master regulator. The other may be connected to the draft passage, or subjected to other conditions depending on what it is desired to accomplish.

The combination of machines and manner of operating will depend upon conditions. As an example, a receiving machine may be placed on the stack draft, the fuel feed and the



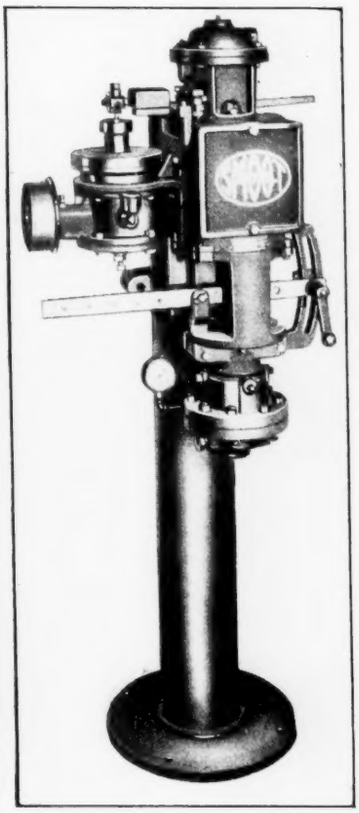


Fig. 1 (Left)—Master controller for the Smoot system of automatic regulation of boiler plants. Fig. 2 (Right)—One of the combustion-control regulators, which are caused to function from the master, Fig. 1, by low-pressure air.

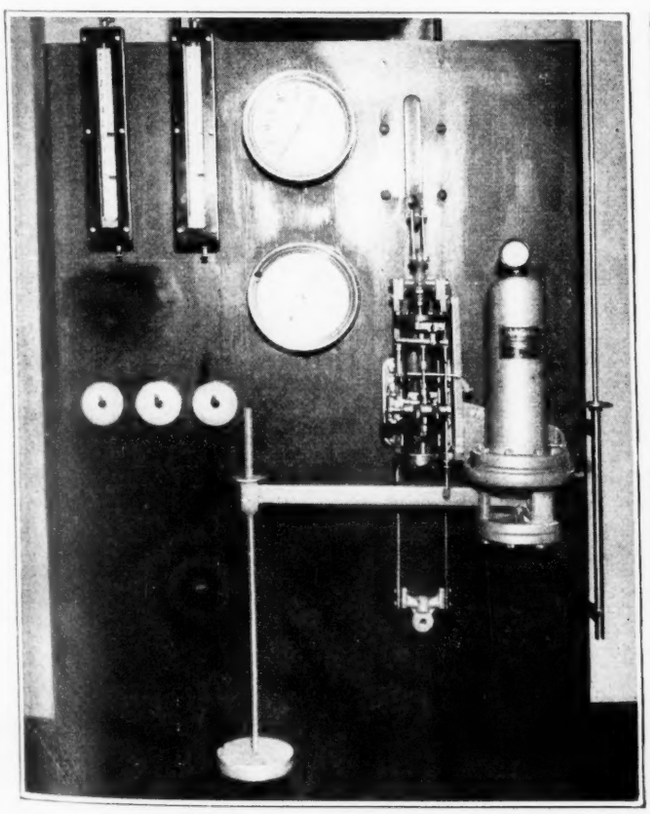


Fig. 3—Master controller for Hagan system of automatic combustion regulation

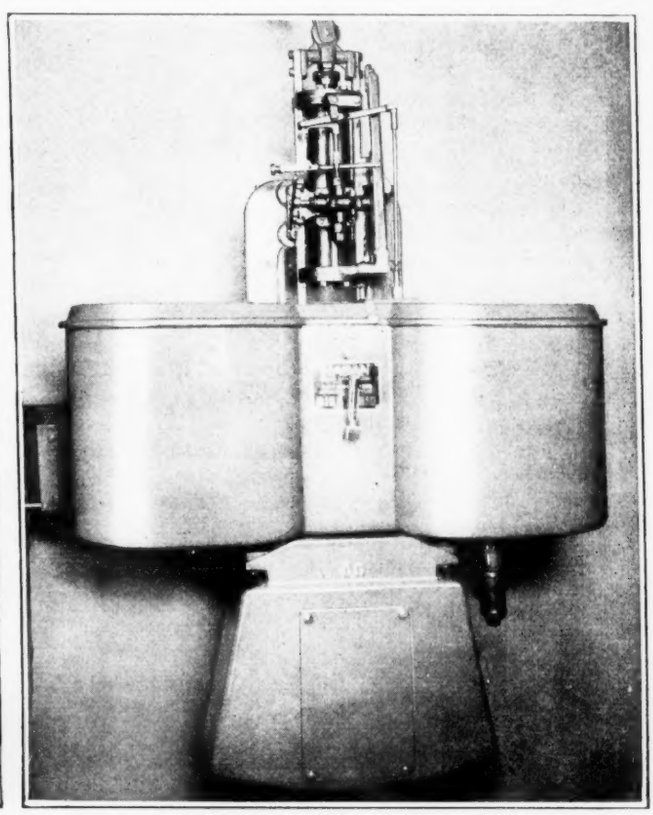


Fig. 4—Air-flow or fuel-feed regulator operated from the master, Fig. 3

forced-draft fans, and a similar machine, functioning from pressure over the fire, used to control the position of the undergrate dampers.

The boiler-plant master may be connected to a master on each boiler, each master being connected to the receiving machines on its particular boiler. Other conditions may require that certain of the receiving machines have a sending device connected to them. Under this arrangement the receiving machines not only get impulses from the master regulator and translate these to operate the combustion equipment, but also send impulses to other pieces of boiler-regulating apparatus.

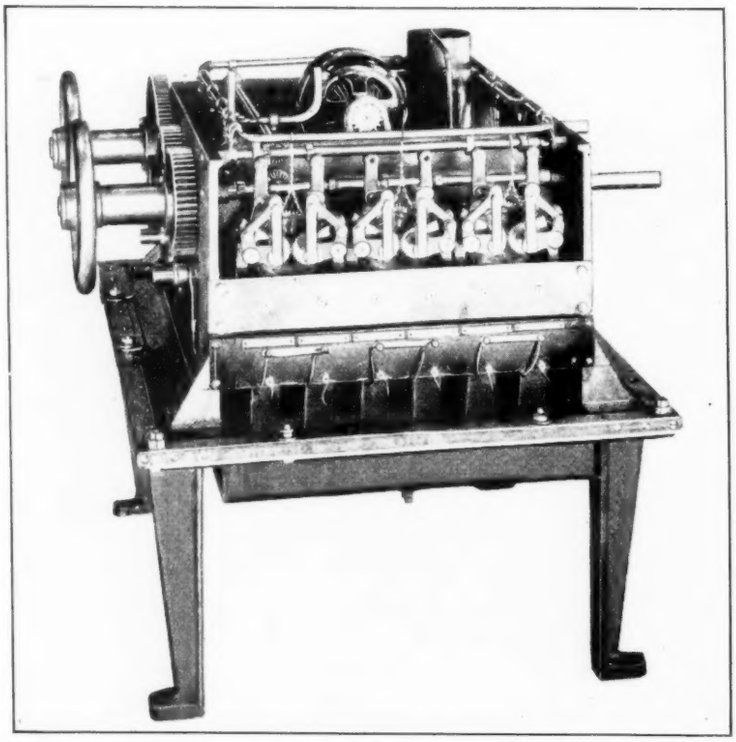


Fig. 5—Power drive for Bailey meter control system for automatic regulation of boiler plants. This system is compensated from the steam-flow air-flow meter

There have been a number of automatic boiler-control systems developed in which the impulses from the master are transmitted electrically. One of these is the Bailey meter control, so called, since the compensation of this system is made by steam-flow air-flow relation. In the master controller a small motor continuously operates a cam to make contacts for more fuel and air if the steam pressure is low or for less fuel and air if the steam pressure is high.

This machine is equivalent to a man watching a pressure gage and pushing a button to operate a remotely controlled motor, except in this case the cam pushes the pressure bar every five or ten seconds. It is also designed so that the length and frequency of the contacts depend upon the pressure deviation from standard and whether it is going from or returning to standard pressure. Whether the rotating cams close the control circuit or not depends on the position of a pressure pin carried on the end of an arm actuated by a Bourdon tube connected to the steam header. As long as the pin remains in the standard-pressure position, no contact is made. Any deviation of the pin from this position causes the control circuit to be closed for more or less fuel and air, depending upon the change in steam pressure.

The electrical impulses sent out from the master controller energize solenoids in the control drive, Fig. 5. This drive comprises a continuously running motor driving a system of gearing, controlled by solenoids. When these solenoids are energized by circuits through the master controller, clutches are closed and this causes the drive to function to advance or retard the fuel and air supply.

Any deviation from the desired steam-flow air-flow relation for each boiler is compensated for by a contact closing on the steam-flow air-flow meter, which energizes a solenoid in the control drive. This solenoid closes a clutch for more or less air according to the conditions to be satisfied. In this way any variation in the boilers' operating conditions is compensated for and a definite relation between steam-flow and air-flow maintained.

In the Leeds & Northrup system the operating medium is a direct electric current, to which the combus-

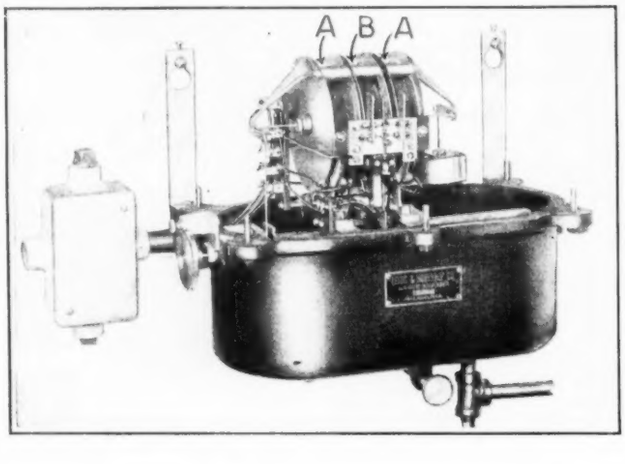


Fig. 6 (Left)—Fuel-feed or air-flow controller to operate from the master, Fig. 7

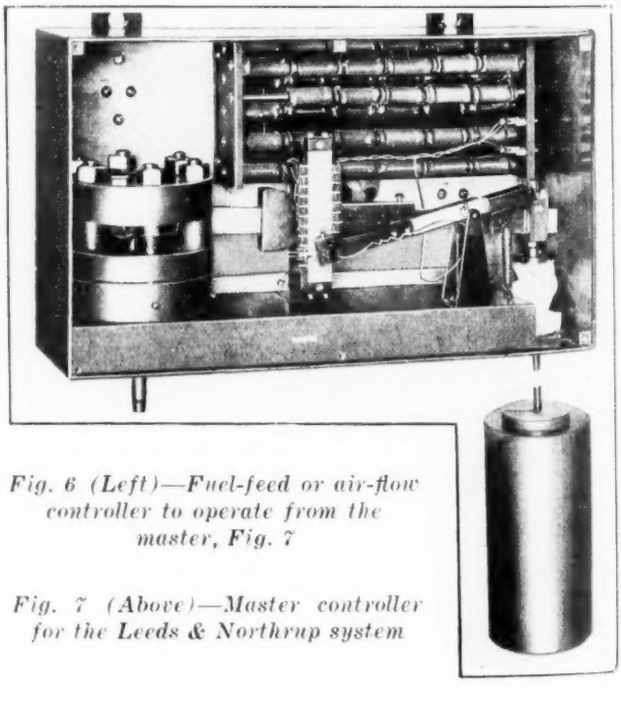


Fig. 7 (Above)—Master controller for the Leeds & Northrup system

tion rate in proportioned. The master regulator, Fig. 7, consists of a rheostat that is in series with the operating circuit. This rheostat is adjusted by variations in boiler pressure acting on a loaded diaphragm attached to the rheostat contact arm.

Motor-driven power units are used to operate the fuel-feed and draft-fan controllers and to change the position of the dampers. The air-flow and fuel-feed controllers are operated on the principle of a dynamometer type voltmeter, having two stationary coils *A* and one movable coil *B*, Fig. 6. To the movable coil is connected a contact arm, which, when in the closed position energizes circuits to change the rate of fuel feed and air flow, the latter by the stack damper or induced-draft fans. A furnace-pressure regulator operates the under-grate draft to maintain the furnace pressure. The current in the movable coils of the air-flow and fuel-feed controllers is regulated by the master rheostat, so that any change in the setting in this rheostat, due to change in steam pressure, results in a change in the air flow and fuel feed. The air-flow control is compensated by the pressure drop across the boiler passes and the fuel feed control by a small blower driven from the fuel feed.

On the Engineer Co. electrical system a motor-driven power unit is used in both the master controller and the receiving units. The connection between the continuously running motor and the device to be operated is made by two pawls that are continously oscillated. Under an established set of conditions of boiler operation, the pawls are prevented from engaging the pawl wheels by a carrier that is under the control of two coils.

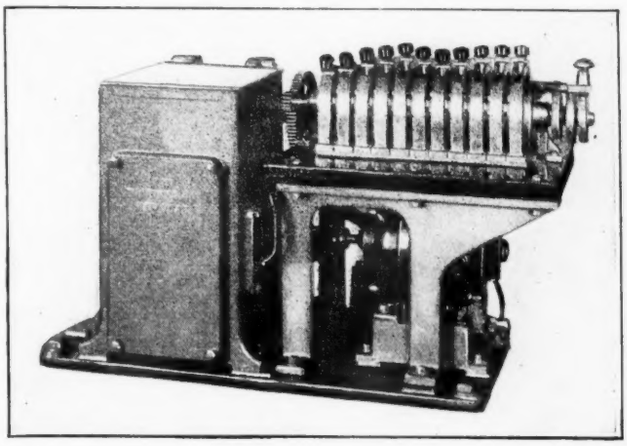
The master controller, Fig. 8, consists of one of these power units, a Bourdon-tube type pressure switch and a dial switch, the last not shown. A change in steam pressure causes a contact on the pressure switch to close and energize one of the two coils on the pawl carrier and holds this carrier in a position to allow one pawl to engage a wheel and move the arm on the dial switch, which closes a circuit to the receiving machines on the various draft-control and fuel-feed devices.

These receiving machines comprise a power unit and a cylindrical switch on which there are two contacts (one forward and one reverse) for each contact on the dial switch. The cylindrical part of this switch is divided into halves, which are insulated from each other, so that when a contact is energized from the master this circuit is interrupted when the cylinder turns to a position where the contact comes on an insulated part.

When the dial switch or the master is moved on a contact, it energizes one of the coils on the pawl carrier in the receiving units and connects these units to the combustion-control devices to be operated, and moves them to a new position, where they are stopped by the receiving switch turning to a position where the circuit through the pawl carrier coil is interrupted. In this way the fuel feed and draft are increased or decreased in definite steps.

On each ring of the cylinder in the receiving unit there is an adjustable contact for each point on the master controller switch. These contacts are adjustable circumferentially around the rings, so that the receiver can be made to vary the characteristics of the device being controlled through wide ranges and all the receiving units may be adjusted differently if desirable.

Only the briefest outline has been given of these systems referred to, and no attempt has been made to describe the refinements incorporated in them to obtain complete control of combustion processes under various conditions. For those who are interested in a more detailed description, the Smoot system was explained in the issue of May 16, 1922, page 771; the Enco, May 11, 1926, page 711; the Bailey, Aug. 10, 1926, page 198; and the Leeds & Northrup, Oct. 26, 1926, page 626. A complete story on the Hagan system is expected in the near future.



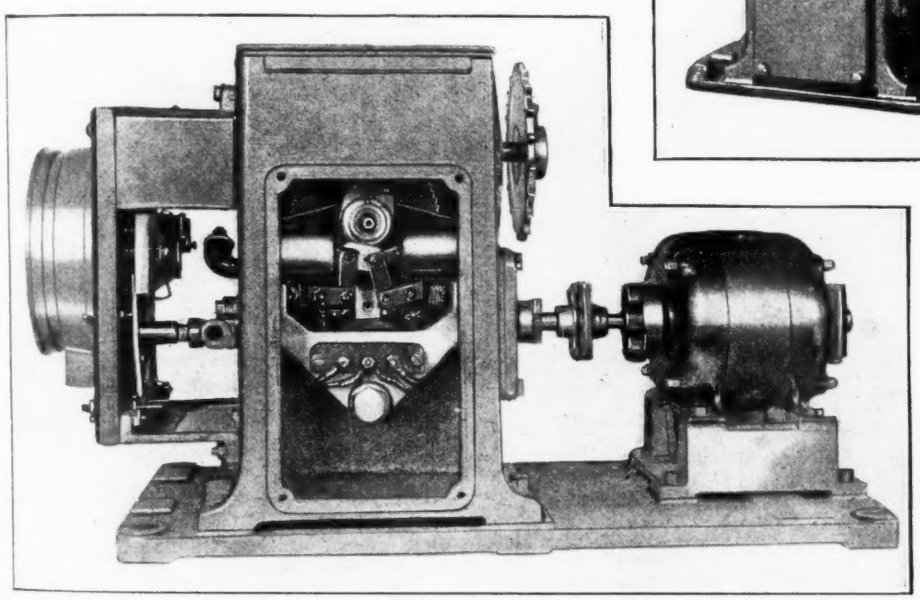


Fig. 8 (Left)—Master controller for the Engineer Co. system

Fig. 9 (Above)—Receiving machine which operates on impulses from the master for changes in fuel feed and air flow

The Mercury Vapor Power Plant at Hartford

PIONEERING is always fascinating and the mercury vapor process development is a noteworthy example of pushing engineering advancement into new fields. Dr. W. LeR. Emmet and other General Electric engineers, together with the Hartford Electric Light Co., carry the honors in this case. In *Power* for April 12, 1927, appeared a report of a description and discussion of their latest design, but that account was unfortunately without illustrations. The release of the layout will give a clearer picture of developments.

DEVELOPING a 10,000-kw. generator driven by a mercury vapor turbine has involved the building of several boilers and turbine units in the process of overcoming difficulties one by one, and at last a design has been worked out that seems to present a well-founded prospect of continuous, reliable and efficient operation.

Briefly, the equipment comprises a mercury boiler, fired with pulverized coal, a mercury vapor superheater, a mercury economizer, a combustion air preheater, a mercury vapor turbine, a heat exchanger that is at once a mercury condenser and a steam boiler, and a steam superheater through which steam passes to the steam plant in connection with which this mercury unit operates. The arrangement of this apparatus is shown in Fig. 2.

The mercury boiler presents the most unusual features of design. It is made up of seven drums, each fitted with 440 tubes, 6 ft. long, extending from the drum in the shape of an immense brush. Each tube, as shown in Fig. 1, is a $2\frac{3}{4}$-in. outer tube, with the lower end closed by a drawn steel cup welded to the tube body. Within are two tubes to insure proper circulation for the liquid mercury. The inner tube, about one inch in diameter, conducts liquid from the drum to the bottom of the dead-ended tube. This is surrounded by a filler tube, with a dead air space between, so that little heat is transmitted to the liquid on its downward course. This is done to prevent vaporization which would tend to reverse the circulation. Between the outer filler tube and the boiler tube proper is a space $\frac{1}{8}$ in. thick in which vaporization occurs, the vapor and heated liquid rising into the drum. The outer, dead-ended tube is calorized, except for the upper six inches of its length, where it enters the drum wall and is welded in place. Tubes of this construction have been subjected to severe tests without failure.

Since mercury is both expensive and heavy, the boiler drums are fitted with solid cast-iron fillers, which are both cheaper and lighter than mercury. These are bolted down to prevent their floating, and their shape is devised to promote regular circulation within the drum and tubes. The drums are insulated to keep their temperature down, since the flue gas passing between them will be at a temperature of 1,200 deg. F. Even so the drums will be at high temperature, and to insure safety, they are designed for exceptionally low stress.

Mercury vapor leaves the boiler through pipes that travel altogether within the breeching, so that there is a slight superheating effect. This piping is not designed primarily for a superheater, but it does serve as such to a small extent. The primary reason for inclosing this piping within the breeching is to carry up the stack any mercury vapor that would be released in case of failure of piping or connections. A similar provision has been made for valves and other fittings.

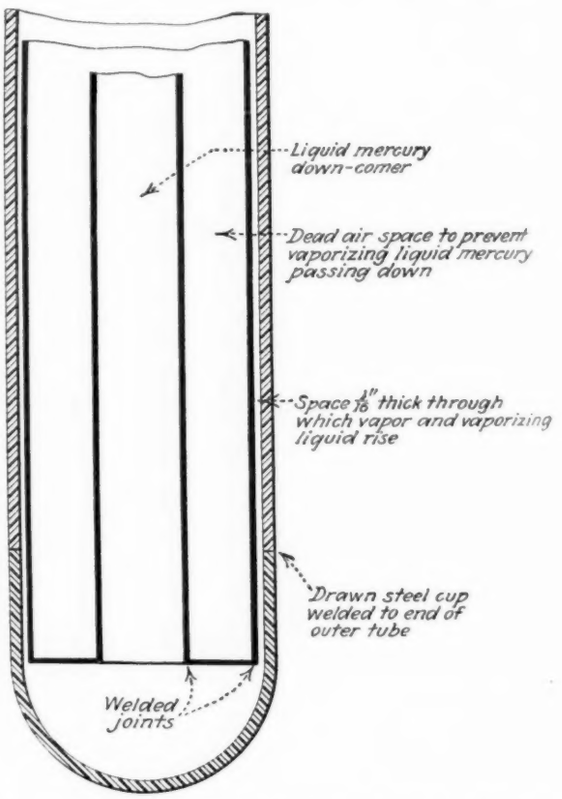

Liquid mercury down-comer
Dead air space to prevent vaporizing liquid mercury passing down
Space 1/8" thick through which vapor and vaporizing liquid rise
Drawn steel cup welded to end of outer tube
Welded joints

Fig. 1—Each boiler tube is a dead-ended tube with a special filler and circulating tube within it

Flue gas leaving the boiler bathes a group of pipe coils through which liquid mercury is returning to the boiler, and the liquid is thus heated before it enters the boiler. The flue gas next passes through a steam superheater and thence downward through an air preheater into the induced-draft fan. A forced-draft fan drives air through the preheater to the burner system. Pulverized coal has been chosen so that the fires can be extinguished immediately in case of trouble, to avoid excessive loss of mercury vapor through the stack.

Liquid mercury flows by gravity from the condenser to the boiler, the head being sufficient to overcome the pressure difference. There are no mercury feed pumps.

The mercury vapor safety valves are located in a chamber with the turbine governor valve, and this chamber is connected to the induced-draft system, so that if any mercury vapor leaks out, it cannot enter the atmosphere of the room. The safety valves discharge into the mercury condenser, to avoid waste of mercury. Instead of stuffing boxes, all mercury valves are fitted with specially made bellows of the sylphon type, made up of steel rings and sheets welded together.

The turbine presents no unusual mechanical details, but has of course involved an intensive study of materials suitable for the service. The nozzles and buckets are of steel, and experience with earlier units indicates that bucket erosion will not be a serious matter. Since mercury vapor has a high density and a low heat content per pound, the jet velocity is lower than that of steam for the same pressure drop. This makes it possible to secure good efficiency with a low-speed turbine of few stages. In this installation the turbine has five stages and runs at 720 r.p.m. The entire rotor is overhung from a bearing at the low-pressure end, so that there is no high-pressure shaft packing. The low-pressure shaft packing is sealed with illuminating gas to prevent the entrance of air into the mercury system. Air is objectionable because it would tend to promote oxidation of the mercury, and the oxide might obstruct the thin vaporizing space in the boiler tubes. Some months of continuous running with a previous unit indicate that this action can be effectively prevented.

In examining the turbine drawings, one is struck with the fact that mercury vapor does not expand as rapidly as does steam. Whereas in a steam turbine the exhaust blading will be thirty or forty times the length of the first-stage blading, in the case of the mercury turbine the difference is much smaller. Of course the principles of design are precisely the same, but the properties of the vapor are distinctly different. Before the turbine could be designed, the properties of mercury vapor had to be determined in the laboratory, and the success of the turbine designer in securing and using accurate data is indicated by the efficiency of 75 per cent that is expected for this turbine, based on the Rankine cycle for mercury vapor.

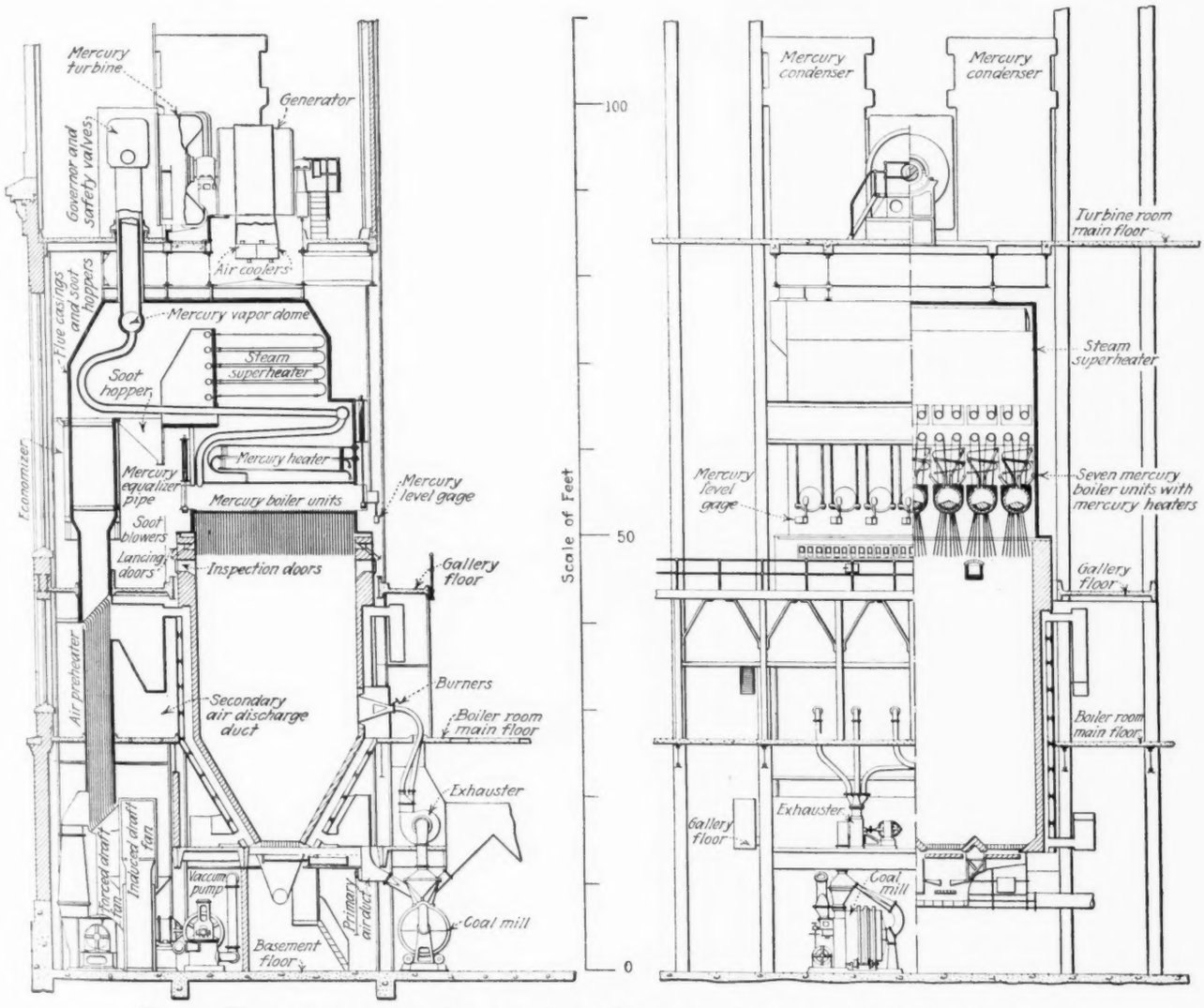
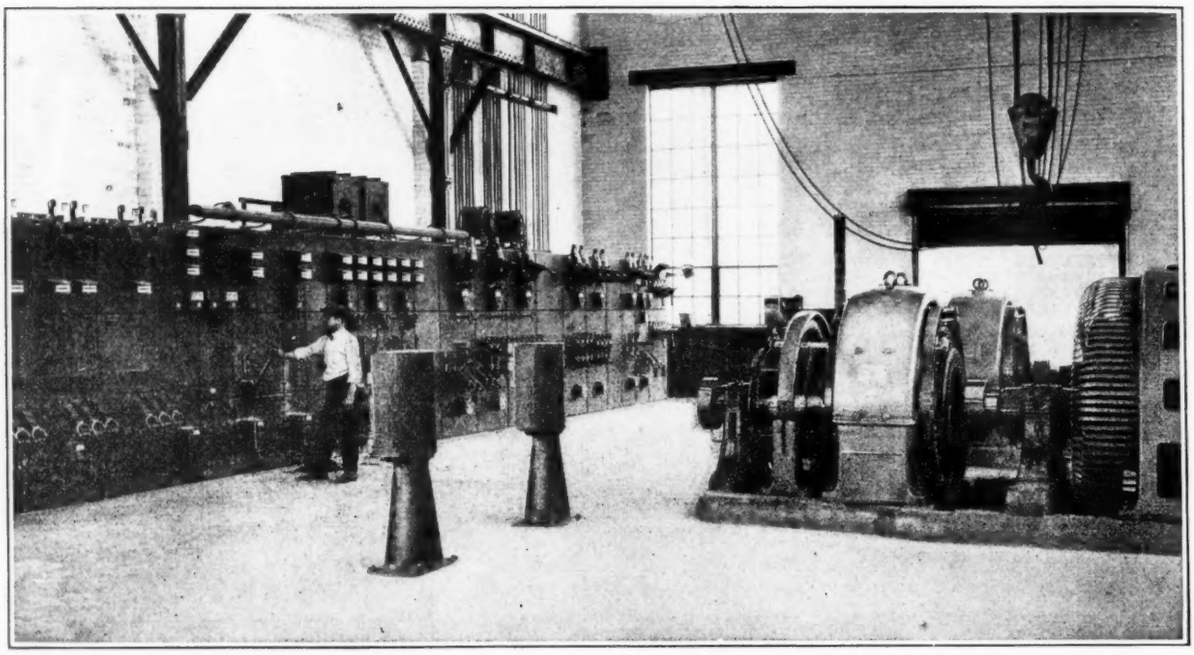


Fig. 2—The mercury vapor plant is to be a self-contained unit located in the boiler room of the South Meadow station

Thanks are due to T. H. Soren, vice-president of the Hartford Electric Light Co., for permission to publish this drawing.



Electrical Protection of Generators in Industrial Power Plants

By ARTHUR J. WHITCOMB*

BOTH direct- and alternating-current generators are used in industrial power houses. However, the prevailing practice is to use alternating-current generators for connection to prime movers, while direct-current generators incorporated in motor-generator sets, together with rotary converters are used for converting the direct-current power required. Hence a discussion of the protection of generators in the modern industrial power house may deal mainly with alternating-current generators.

Protection of the electrical generating equipment in the industrial plant differs in many respects from that in the public utility plant. The extent of overhead lines is very small as compared to the utility system. Hence the possibility of damage by lightning is greatly reduced. In many industrial plants the feeders and distribution circuits are entirely inside of buildings or underground, thereby practically eliminating possibility of damage by lightning.

A further difference is in the switching equipment required. Owing to the relatively small generating capacity in many industrial plants, switches may be used that have much lower rupturing capacity than those used in central-station power houses. On the other hand, purchasing power from the utility, or interconnecting the industrial power plants with central stations entails the use of switches having capacity sufficient to rupture the maximum current that can be delivered to the switch by the public utility and industrial power plant. Also, on some of the large industrial-plant power systems electrical conditions exist that are comparable with those on central-station systems.

Protection of alternating-current generating equipment resolves itself into the following main items:

1. Protecting machines against overspeed.
2. Safeguarding generator bearings.
3. Protecting the generator windings against overvoltage, excessive current, dirt and overheating.

Protection against overspeed is obtained by emergency trips to supplement the governors controlling the prime movers. In steam plants the overspeed trip is installed primarily to protect the prime mover and incidentally provides protection for the generator. The overspeed devices are generally arranged to trip at 8 to 10 per cent overspeed. Frequent tests should be made on them to insure that they are in good working order.

Usually, no further safeguard, other than thermometers placed on the individual bearings, are provided for the generator bearings. In some cases, however, thermostat relays are utilized, the thermostat unit being embedded in the bearing and arranged to trip a relay usually when a temperature of 100 deg. C. is

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reached. Upon reaching this temperature this relay causes an alarm to be sounded.

The windings of a generator should be protected against several possible occurrences. These are:

1. External faults, such as excessive current, either from sustained overloads or short-circuits external to the generator.
2. Internal faults, such as grounds, phase-to-phase short-circuits, short-circuited turns and open-circuits.
3. Excessive voltage generated in the windings.
4. Dirt deposited in the windings from the cooling air, thereby weakening the insulation.
5. Fire in the windings.
6. Overheating.

Alternating-current generators are not ordinarily protected against overcurrent caused by overload. Only in the case of small installations should overload relays be used on alternating-current generators in the industrial power house. In such cases an inverse time, or definite time, overcurrent, or overpower relay is used. In the moderate and larger capacity industrial power houses, better operators are employed, capable of supervising and restricting the load on the generators so that the machines will not be subjected to sustained overloads.

There is a possibility of sustained overload when two power houses are operating in parallel, particularly if one is a large, centrally located plant and the other a smaller installation to utilize waste heat or fuel at a convenient location. A good example of this is found in a large steel plant in the Chicago district. Here a large power house adjacent to the blast furnaces utilizes the blast-furnace gas and also burns coal as a supplementary fuel. The open-hearth furnaces are some distance away. The stack gases from the open hearth are passed through waste-heat boilers. The steam thus derived is used in a second power house, adjacent to the open hearth. This plant is tied in with the main power station. Since the main power house is much larger than the second, reverse-power relays are installed on the single generator in the small plant to prevent power from flowing from the main station into this generator, should the overspeed trip on the prime mover act or similar emergency conditions arise.

Short-circuits external to the generator, may occur on the distribution system. Overload relays on the feeder oil switches is the method used for protecting the generators against these shorts. Inverse-time-limit relays are connected to each feeder circuit breaker so that in case of a short-circuit on that feeder the breaker will be tripped open, thereby localizing the fault and protecting the generating equipment.

To alleviate the effect of short-circuits on the generators and oil switches, reactance is sometimes placed in the feeders. Use of reactance in the feeders may reduce the size of oil switches required. They also reduce the momentary peak current flowing through the generator, thereby diminishing the stresses set up in the generator windings. A high-reactance generator is of advantage not only in case of short-circuit, but also in limiting the current that will flow if the machine is connected to the system somewhat out of step.

Reactors are not commonly used in the industrial power plant for the reason that the capacity involved in many cases is too small to warrant their use. However, in case of interconnection with a public utility, reactors are sometimes used to advantage to reduce the oil switch capacity that would otherwise be required.

A discussion of protection against internal faults, as mentioned, hinges to a large extent on whether or not the power plant is operating on a grounded or ungrounded system. Extensive high-voltage systems may well be grounded, unless absolute continuity of service is essential.

On large public utility power systems, it is customary to ground the neutral either solidly or through a resistance. In the industrial plant, however, the system is generally operated with the neutral ungrounded, for the following reasons:

1. The voltages encountered are moderate;
2. The equipment is generally of smaller capacity than that of the utility and is capable of withstanding the lesser voltage strains that will be encountered;
3. Transmission lines and underground systems are less extensive;
4. Continuous service is of utmost importance; and
5. The use of a grounded system involves more relay and current transformer equipment.

CONTINUITY of power service is of primary importance in industrial plants. In many cases these plants depend entirely upon their own generating equipment. Interruptions are always undesirable and cause loss of production. Lack of proper protection may be the cause of serious damage to the plant equipment. For these reasons protection of generating equipment in the industrial power plant is vital and deserves careful consideration. In this article, protection against overspeed, overheating of bearings and windings, overvoltage, and dirt on the windings are considered.

Relay protection against grounds is not provided at the industrial plant operating on an ungrounded system. A ground detector, however, is commonly connected to the busbars, to indicate the existence of a ground. Steps should be taken to clear a ground as soon as it is indicated.

The remaining internal faults, mentioned in item 2, are phase-to-phase short-circuits, short-circuited turns and open circuits. A differential relay arrangement is used for protection against these faults. Inasmuch as the existence of any of them will cause an unbalanced current to flow through the generator, a differential connection using overcurrent relays is common.

This method of operation will permit of relatively low current settings on the relays since no current flows in the relay coils under normal conditions. It is also free from trouble due to circulating current, when synchronizing or switching, for such currents will be balanced. This arrangement is flexible in its application and may be applied to machines of any size, either star or delta connected, provided both ends of each phase winding are brought out for connection to current transformers.

Probably 90 per cent of the generators now manufactured are star connected. It is to the star-connected generator that the differential-relay connection is most easily adapted. The connections are shown in Fig. 1. Only six current transformers are required, three in the line leads and three in the neutral leads. In the figure the current transformers are shown connected in the

leads immediately after they are brought out of the generator. With this arrangement only that portion between the current transformers—that is, only the generator winding—is protected. If the line side current transformers were located at the oil switch connecting the generator to the bus, the relays would protect not only the generator winding, but also the leads connecting the generator to the oil switch.

Delta-connected generators are not now so commonly used. A balanced connection of relays for a delta-

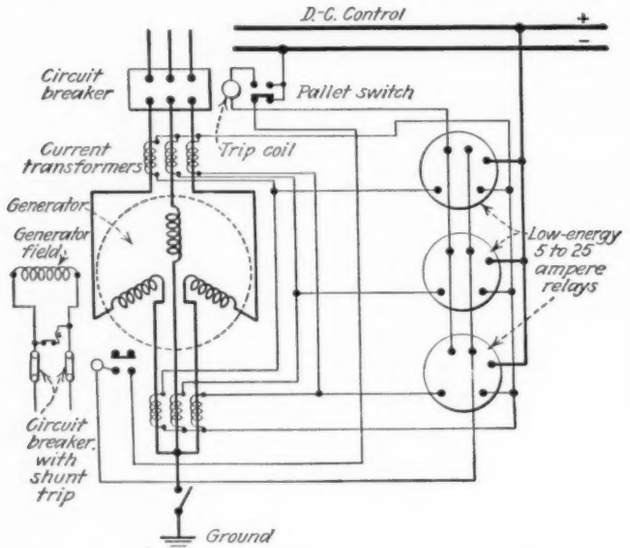


Fig. 1—Differential connection of current transformers and relays to protect winding of star-connected generator against internal faults

connected generator is shown in Fig. 2. This diagram shows how nine current transformers are required in order to protect the leads running from the generator to the oil switch as well as the generator winding.

The relays used with these two methods of protection are generally of the inverse-time induction type, although instantaneous relays may be used.

It is necessary to provide over-voltage protection for the generators. Over-voltage may occur in a generator in the event it is disconnected from the busbars through the action of the protecting relays. Under such a condition the generator would operate at no load with the excitation required for the load the generator had been carrying. As a result the voltage would rise, possibly to an excessive value. If only one generator were operating at the time it was disconnected by the relays, the voltage regulator would cause full field to be applied to the generator, for the regulator is governed by the busbar voltage and the latter would be zero in this event. To prevent this action, a circuit breaker is connected in the field circuit. This circuit breaker is tripped by a shunt trip, actuated from the contacts of the relays that trip out the oil switch in case of a generator fault. The field circuit breaker and trip connections are shown in Fig. 1.

An essential part of the protection given to generators is the provision made for cleaning and cooling the air supplied for ventilation. Dirt carried into the machine by the cooling air restricts the ventilation and will form a conducting coating on the insulation that in time might cause it to break down.

Cooling systems may be divided into two main classifications—the open system and the closed system. With the open system a continuous supply of air is cleaned, or both cleaned and cooled, passed through the generators and then exhausted. In the closed system the same air is repeatedly recirculated through the generator and cooler in series and is coming into general use, especially on medium and large units. Experience with this system shows that the windings will remain practically clean for long periods, a condition that does not obtain with the open system with air washers or filters.

Protection against overheating of the stator windings is best provided by measuring their actual temperature. This is accomplished by placing thermocouples or resistance-coil units between the upper and lower coils in some of the stator slots at the time of manufacture. An instrument is connected to these units to give a record of the generator's temperature.

There are many variables entering into the question of how much load a given generator can carry. Aside from considerations and limitations of the prime mover, power factor, voltage and temperature of the incoming cooling air all have a direct bearing on the load that may be safely carried. It is becoming the practice to govern the generator loading by the operating temperature of the windings as shown by the recorder.

Generator exciters are in general not provided with any protection. Circuit breakers, overload relays or any devices that would disconnect them in case of trouble, would affect the generator or generators that

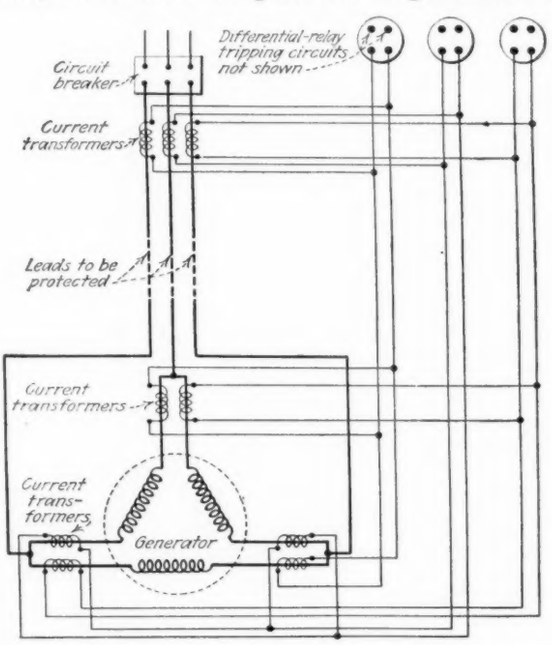
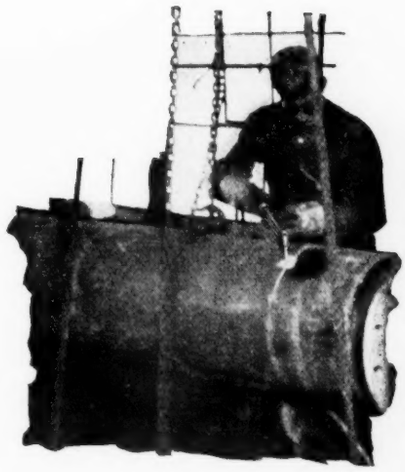


Fig. 2—Balanced connection of relays and current transformers to protect winding of delta-connected generator and its leads to oil switch

they supply. It is common practice in industrial power houses to omit all exciter protection. If it is felt that overload devices are required, they should be arranged to ring a bell or otherwise warn the station operator of possible trouble, thereby letting him handle the situation as the conditions indicate.

In the modern industrial power house, exciters directly connected to the generator drive shaft are becoming more common. A direct-connected exciter supplies only its own generator, hence the danger of overload is greatly reduced.

Gas Welding Versus Flange Joints for Steam Lines



Arguments for the Replacement of Flange Joints by Welding—Ability to Stand Thrust and Pull of Pipe Bends—Taking Care of Expansion and Contraction—Importance of Procedure Control—The Insulation Problem—Saving Money on Tunnel Lines—Demand for Flangeless Valves and Fittings

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THE growing use of oxyacetylene-welded joints for steam lines raises many interesting questions about the stresses in steam pipe lines, the expansion fittings to be used and the efficiency of the completed line.

The matter of most concern to designing engineers seems to be the strength of the joint; then the question of dependability arises. Other important factors, such as improved insulation, reduced interference between lines, ease of installation, etc., have scarcely been considered. It is my intention to make an analysis of the strength and stress problem to show how safe oxyacetylene welding is, then to point out a few of the important advantages from its use.

The stresses in a modern steam line equipped *with adequate expansion facilities* are never high even at the bends. With excessive deflection at the bends or if the radius of bend is too short, the stresses may be very high.

Pipe Stresses Are Low

A paper on the "Elasticity of Pipe Bends," presented at the annual meeting of the A.S.M.E. in December, 1922, by S. Crocker and S. S. Sanford, showed that for the largest curves ordinarily considered for an 8-in. double-offset expansion U-bend (120-in. radius) a deflection of 5 in. would put a stress of 4,000 lb. per sq.in. on the metal, but that the endwise force would total only 1,750 lb., or 18.5 lb. per sq.in. for standard pipe (⅜-in. wall).

For expansion U-bends the stress would be approximately 10,000 lb. per sq.in. and the endwise force would be approximately 5,500 lb. or 60 lb. per sq.in., which endwise force is of small concern.

No information was obtained as to the endwise force required to move a section of pipe at a straight expansion joint, but it is certain that the resulting stress would be small. The ideal line might therefore use such straight expansion joints in its middle sections. This will be commented on later. The use of quarter-bends to take endwise displacement involves careful calculations as the bending stress becomes high, even with slight displacement.

It is apparent that there is no longitudinal stress of any magnitude on the straight sections of a steam pipe line that has expansion provisions. It is therefore apparent that the difficulty in finding suitable mechanical joints for steam lines is not a matter of endwise strength but is a matter of tightness under the effect of temperature changes and the withstanding of considerable pressures.

With oxyacetylene welding, which insures freedom from pinholes and ample strength, there is practically no problem involved at the joint. Such a weld can be counted on for the full strength of the pipe, but no such strength is required, as the stress is almost nil, as has been mentioned above.

Why, then, should designing engineers hesitate to use the oxyacetylene weld for all pipe joints when increasing pressures do not in any way increase the unit stresses if the weight of pipe is proportional? The only answer is that in all mechanical joints the increase of pressure and temperature does offer a serious problem and engineers are thinking in terms of possible trouble at the joint.

For the information of steam engineers it is noted that in many other classes of piping the endwise stresses are far higher than with steam, because expansion and contraction are not provided for. The stresses in an eight-inch oil pipe line operating at 700-lb. pressure, laid in warm weather, reach 15,000 to 20,000 lb. per sq.in. during extreme winter weather. What is the history of these lines? At least two companies have a quarter of a million joints each and have not had a failure.

Few Welded Pipe Failures Known

Hydraulic, air and gas lines are also operated at high pressures without expansion and contraction provisions. Some lines are straightaway, others are around plants and refineries, where they twist and turn. Failure of welded joints is unheard of in many large works. In several years of close contact with welded pipe installations I never heard of any failures in welded pipe lines except in a few cases on large (16-in.) diameter pipe lines with no expansion loops or joints. In all such cases the stresses undoubtedly exceeded 25,000 lb. per sq.in., judged by the amount of separation of the pipe after fracture.

Steam engineers who provide amply for expansion and contraction stresses can therefore assume that past history of welded joints is entirely satisfactory. The

principal thing in any welding work is to follow a simple procedure control by checking workmanship of the welder and the grade of filler rod, using a type of joint suitable for welding (of which the butt weld is to be preferred), fitting the parts together properly, and after welding, applying a test by hammering and looking for pinhole leaks. This procedure control has been the subject of several major papers and should be looked into by anyone interested in the design or construction of pipe lines or of any fabricated structure.

At this time it should be noted that the institution of procedure-control methods of applying welding, including the use of high-test filler metals, has entirely changed the status of welding within three years. Engineers were properly skeptical of welding a few years ago, although the results were excellent where the work was properly done. Now, however, welding should come in for an entirely new and comprehensive study because it supplies the best joint that can be made between metal pieces. As correct specifications for welding and correct management are the sole requirements, American technical men certainly will not fail to measure up to the job of applying the process.

Other Advantages of Welded Lines

Obtaining a joint that solves all the problems pertaining to the carrying of high steam pressures at high temperatures is reason enough for the use of welding, but there are other distinct rewards from its use. The welded joint is the most economical in the matter of heat losses because, first, it has only the area of an equal section of the pipe itself, and secondly, the insulation is more effective over a welded joint because the insulating material may be continuous.

Operating men are familiar with insulation problems at pipe joints. A steam leak under the insulation not only affects the joint covering but frequently results in the saturation of the insulation along the pipe on each side, thus reducing the efficiency of insulation. In many plants the joints are not insulated or the insulation is soon removed so that the joints are free. Uninsulated joints cause appreciable heat losses as noted by Broido in an important article in the "Transactions[1] of the American Society of Mechanical Engineers." The higher the temperature the more important is the bare-flange loss.

The cost of construction of a pipe installation is affected by welding in ways other than the cost of making the joint where welding is far the most economical. In the drawing office layouts need only show the outside dimensions of the covered pipe, as a check on clearance, and where valves and expansion joints should be placed. With other than butt-welded construction plans must frequently be made as to location of joints to prevent interference in tight places. Much pipe work is done in such places.

Welding Permits Increased Shop Fabrication

A great deal of the welding and of the insulation can generally be done away from the final location, so called "tie-in-welds" being used to complete the installation. There are two distinct advantages from this, as follows:

First: All manifolds and special shapes, which would include all neck welds and all expansion bends, would be shop fabricated, and given severe shop tests by supplying high pressure hydraulically, then hammering all welds while under pressure. This would insure excellent welds, at the points where stresses are highest.

Second: Long straight leads in tunnels or through buildings could be made by welding several lengths together, insulating them, then pulling the completed section over the rollers or through the hangers. When the end of a section reached the welding station, a similar long section would be welded to the first, then the insulation would be carried along. This permits the use of narrow tunnels or permits the installation of many pipes in an average tunnel.

The limiting length for so handling long leads of pipe is, of course, the distance between fittings, but where "tie-in welds" are to be made, the space required is no greater than for bolted joints.

At the present time the only obstacle to having an all-welded installation is that cast valves and fittings are made with flanges. Forged valves are as easily made with skirts for welding as with flanges for bolting. The cast valves could also be made with skirts, so there is no serious objection to having an all-welded system including all valves and fittings.

Valves Should Be Furnished Without Flanges

In one city where welding is extensively used, the steam pipe line maintenance men cut the flanges off the valves and weld to the main line whenever difficulty is experienced at any flange joint. It would seem that valve manufacturers should be prepared to supply valves for welding, otherwise the valve flange will soon become the most troublesome part of a high-pressure system.

The same thing that applies to valves concerns other fittings such as meters. Study will be required to adapt some parts to welding, because certain parts need to be accessible and, when welded in, no part can be replaced except by cutting it out with a torch or pipe cutter. The cutting out of a valve and welding in of another is neither a lengthy nor a serious matter. In fact, it is probably as fast and simple as making a new flanged joint.

An Ideal System

Based on the foregoing study, it seems that an ideal steam installation would be made up as follows: An expansion bend at each terminal to take endwise stress off boilers and engine, anchors and hangers about as at present, straight expansion joints at all intermediate places for expansion and, lastly, all joints from boiler to engine (including valve joints) to be oxyacetylene welded. In such a system pressure and temperature would be no problem short of those temperatures where the materials of construction would lose their strength. If materials can be found to stand up under the heat of generation of the steam, the carrying of the steam should not add to the problem.

Conclusion

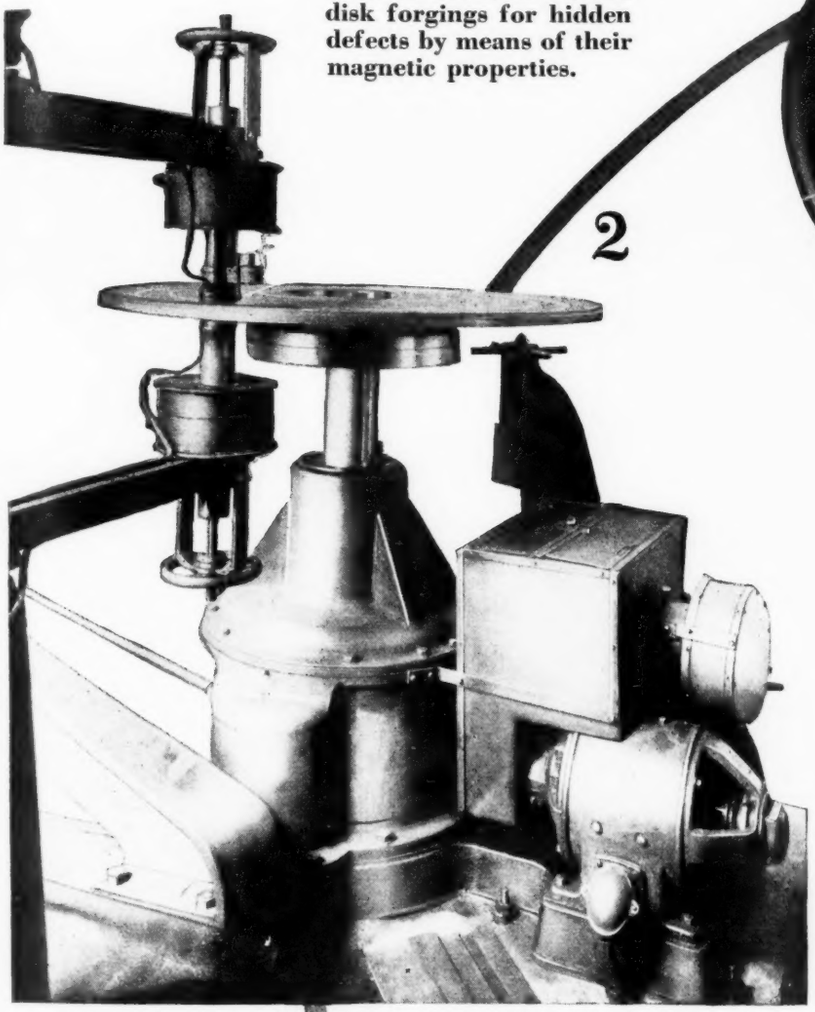
The method of joining steam pipe should no longer be a problem because, owing to provisions for expansion and contraction, the joints in steam systems have little if any endwise stress, yet they can be made by oxyacetylene welding so as to be absolutely tight up to the limit of strength of the pipe, and such welding offers the strongest joint that can be made.

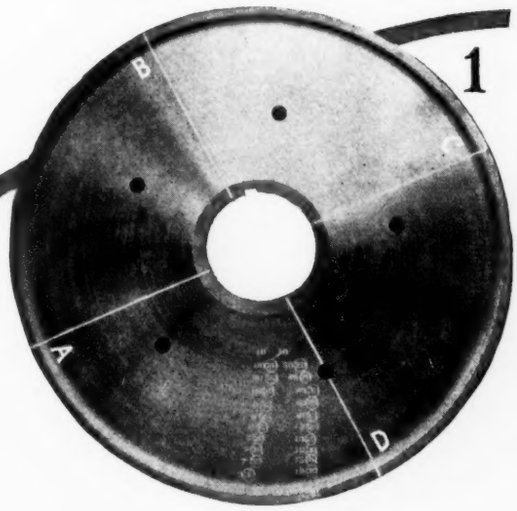
Many economies result from the use of oxyacetylene welding with regard to efficiency of insulation, reduced expense for designing and simplification of erection.

[1] Volume 44, 1922, page 1205.

Magnet Reveals Hidden Flaw in Rotor

THESE pictures show how the General Electric Co. tests turbine disk forgings for hidden defects by means of their magnetic properties.





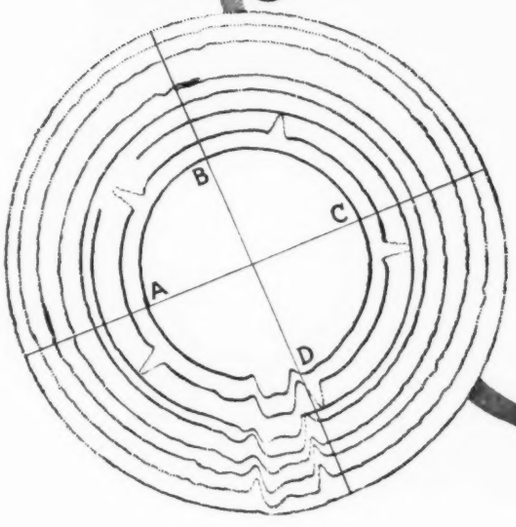
1 The disk is laid off with reference diameters. The other marks shown in this picture were put on after the test, to located suspected areas.

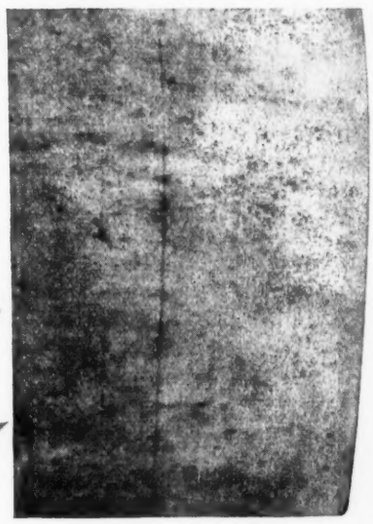
2 The disk is then mounted in this machine, which rotates it slowly between the poles of a magnetic device which has one pair of coils to energize the magnet and another to detect variations in the strength of the magnetic field.

3 The detector coil is connected to an instrument that records variations in magnetic field. With constant magnetizing current any variation in field must be due to a modification of the magnetic circuit, and since other things are constant, this must be in the forging under test. The second circle from the center shows "bumps" for the five steam-pressure balancing holes, and near diameter *D* is a series of disturbances that indicate a flaw within the forging.

4 The condemned disk, when cut open along the line of the magnetic irregularities, shows a slag inclusion that might have led to failure if the disk had been passed on simple visual inspection.

Photos by courtesy of the *General Electric Review*.





New $700,000 Power Plant for Chalfonte-Haddon Hall Hotels

Land Limitation Necessitates Six-Story Building — Many Novel Features Incorporated in the Design — New Plant Proves Efficient and Reduces Operating and Maintenance Expense — Operation Discontinued in Two Old Plants

WHEN steam was admitted to the first engine in the new $700,000 power plant of the Chalfonte-Haddon Hall Hotels at Atlantic City, N. J., in November, 1926, operation was started in one of the most modern plants used for hotel purposes. Designed to occupy a minimum of ground space and to supply the lighting, heating and refrigeration requirements of these hotels, four employees' hotels and the boardwalk shops, it presents a pleasing appearance, and the construction embodies some rather unusual features.

A new power plant was erected for the Chalfonte in 1902. This and the old Haddon Hall plant were designed to take care of their respective power, heat and light requirements, and provisions were made to permit the installation of additional apparatus for future demands. As various extensions were added to the hotels and other buildings acquired, the boiler, refrigerating and generating capacities were increased in proportion. This continued until 1925, when these plants were being operated at their maximum capacity, and all available floor space had been utilized. It became necessary to decide whether the old plants should be revamped for increased capacity, or a new plant erected. After careful consideration of all factors involved, it was decided to erect a new structure and install modern apparatus of such capacity as would take care of the total requirements and provide for expansion in the future.

Since the land was limited, a decision was reached to design the plant so that it would occupy a minimum of ground. It was found more economical and practicable to erect a six-story building and install the apparatus on several floors, than to erect a building to occupy a greater ground area and install the machinery on the same level. A site adjacent to the old Chalfonte power plant was selected as the most suitable, and excavation was started for the foundation in the fall of 1925.

The new building occupies a space approximately 64x72 ft. and is 109 ft. high from the ground line to the roof line. It is constructed of steel with reinforced concrete floors and red brick walls. All footing is wood-piled with piles having a minimum of a 10-in. top and a 6-in. bottom. A shaft is constructed the entire height of the building which is used for the installation of the various pipes carried from the different floors to the tunnel for Haddon Hall service, and a spacious fire tower installed from the basement to the roof provides a safe fire exit. The building is equipped with an automatic sprinkler system. Nozzles installed on the outside of the south wall of the building from the top to the bottom are spaced on 6-ft. centers and operated from the fire pump. This installation permits the forming of a water curtain between the power house and the adjacent frame buildings in case of fire. A 20-in. main extends the entire length of the boardwalk to which the fire pumps of all the important hotels are connected. In case of fire anywhere along the boardwalk, the combined fire-pump capacity of all the hotels is available.

A reinforced concrete tunnel between the two hotels under North Carolina Avenue serves as a pipe duct for the various high- and low-pressure steam and brine lines terminating in Haddon Hall. It is also used for the transportation of ice and other material, and in wet weather the Haddon Hall waitresses use it in going to and from their quarters on the Chalfonte side of the street. It is 10 ft. wide by 7 ft. high, and 250 ft. long. The top is 3 ft. below the mean water level.

The steam heating for the entire group of buildings is accomplished by a low-pressure vacuum system. Exhaust steam is used for this purpose, but when necessary it can be supplemented by high-pressure steam

reduced to the proper pressure. The system operates at about 3-lb. pressure and a 6-in. vacuum produced by a steam-driven vacuum pump at the head of the tunnel directly under the new plant. Two of these units are installed, but only one is required for average conditions. A steam-driven pump is also located in this room to return the high-pressure drips to the feed-water heater.

The engine room apparatus, on the first floor, is arranged uniformly and ample space allowed for access to any part of the machines. Two vertical four-cylinder uniflow engines, 14x18, designed to develop 800 hp. with 140-lb. steam pressure at the throttle, and exhausting against a back pressure of 1½ lb., are installed along the north wall. Each of these engines is direct-connected to a 500-kw. three-wire 250-volt 300-r.p.m. generator, and is used for the lighting and power load. Either has sufficient capacity to take care of the average daily requirements. A 200-kw. synchronous motor generator set is installed between these engines and is tied in with the 220-volt alternating-current system of the local lighting company. This is used as a breakdown unit.

Two 16x36 Corliss engines, each direct-connected to a 12x24 ammonia compressor, are installed along the west wall. They are used for the manufacture of ice, kitchen refrigeration and cooling the water for the guest rooms of Haddon Hall. Each has a capacity of 60 tons of ice per day, and one is held as a reserve unit. The compressors operate at 150-lb. head and 15-lb. suction, and the engines are designed to operate at 140-lb. steam pressure and 1-lb. back pressure. Two 75-g.p.m. motor-driven circulating water pumps are installed on the south side of the room and operate at 30-lb.

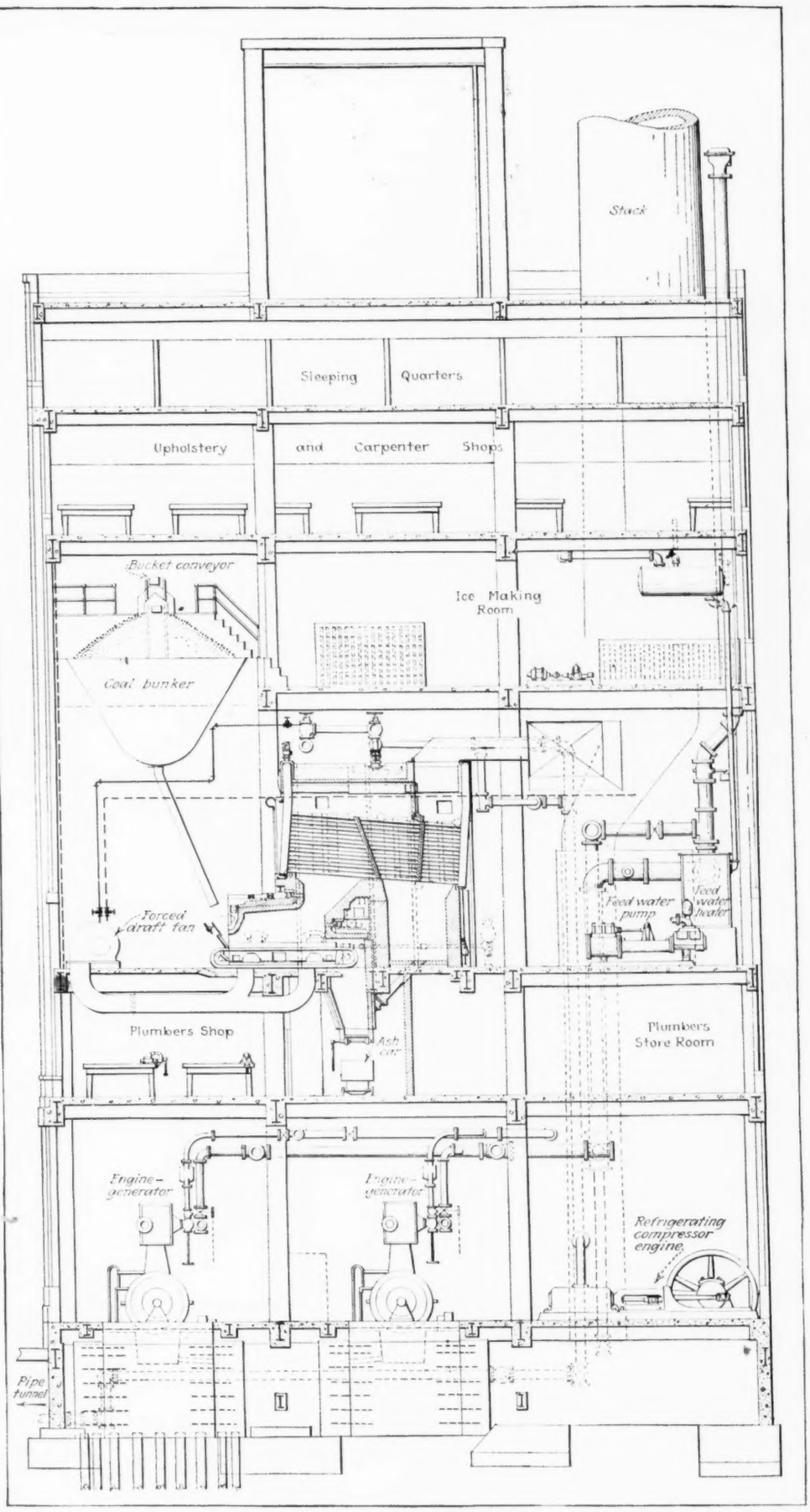


Fig. 1—Section of new power plant, looking south

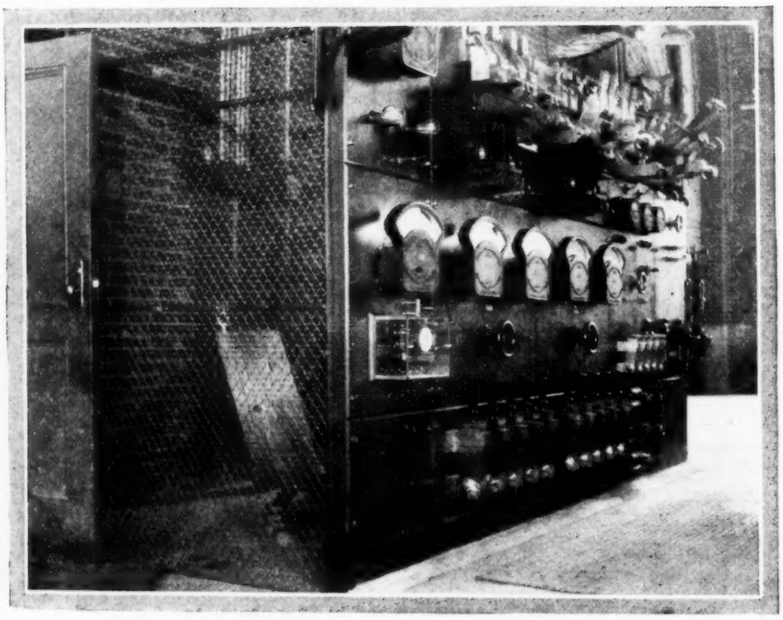


Fig. 2—Motor and generator control switchboard

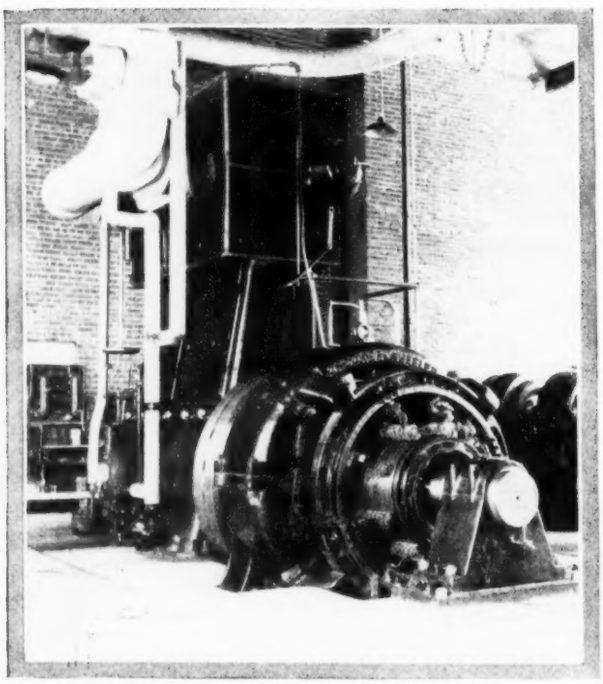


Fig. 3 (Above)—Section of engine room showing engine-driven generator and motor-generator set

Fig. 4 (Right)—Brine circulating and air pumps

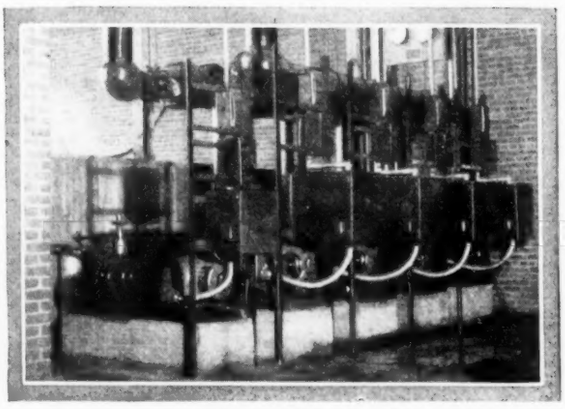


Fig. 5 (Above)—General view of new power house. Red brick with concrete trimming presents a pleasing appearance. Building at the left is the old power house

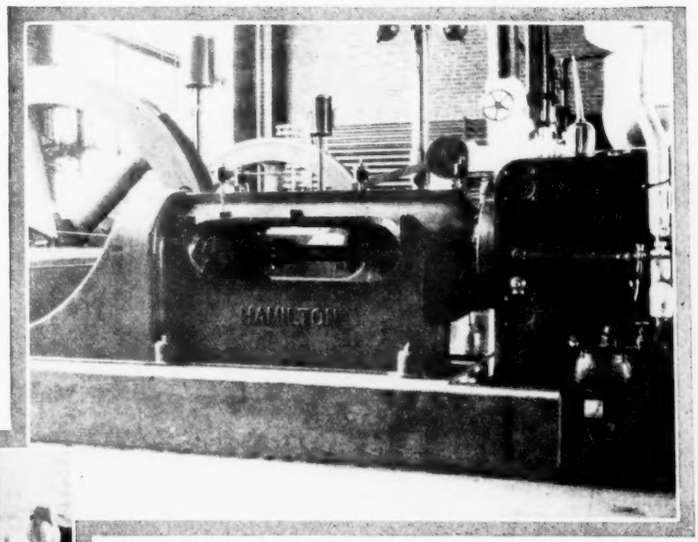


Fig. 6 (Right)—A view of the engine room, showing the engine driving the ammonia compressor

Fig. 7 (Below)—Two motor driven circulating pumps located on the south side of the engine room

Fig. 8 (Below)—View showing stoker-fired boilers, coal bunker and dual-drive forced-draft blower

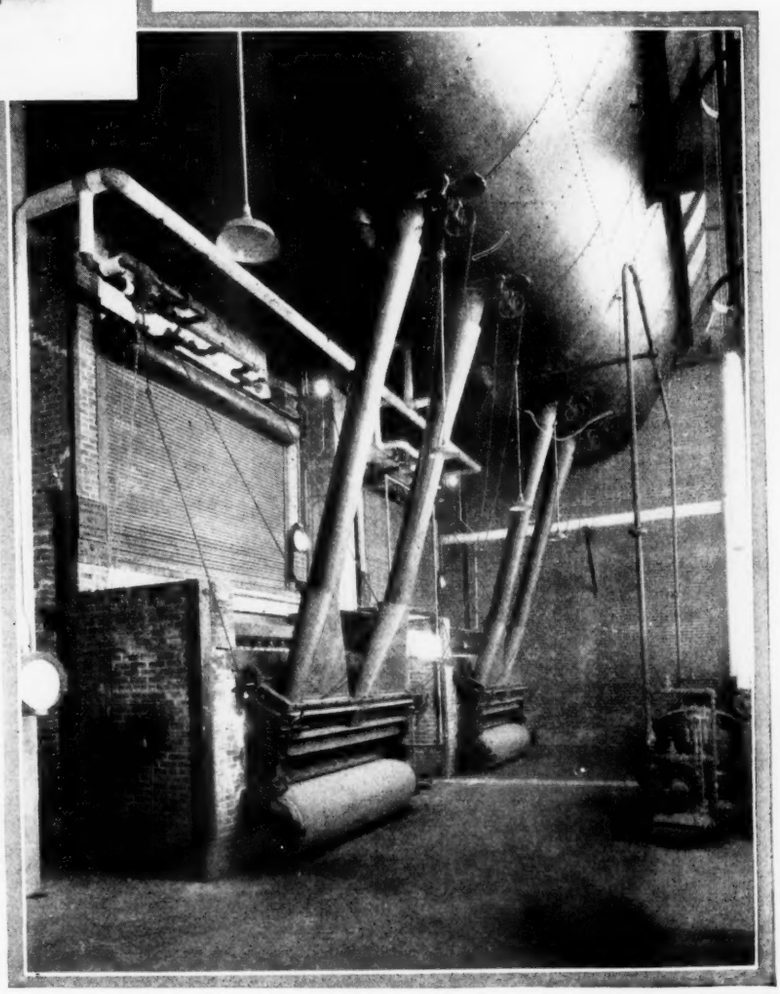
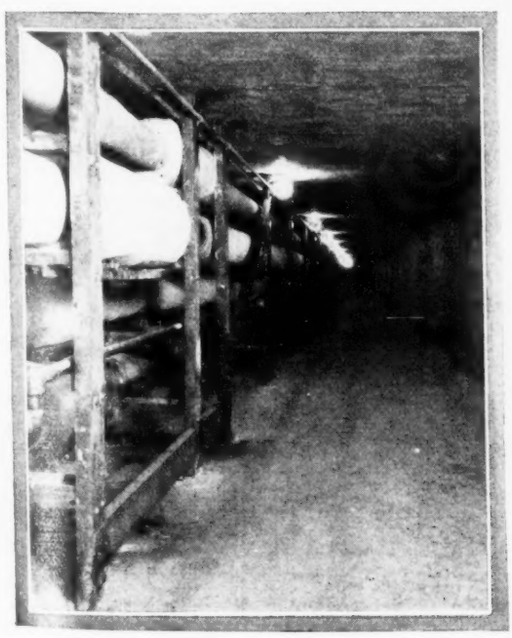


Fig. 9 (Below)—Tunnel connecting the Chalfonte and Haddon Hall Hotels



pressure. They are used for furnishing water for the ammonia condensers on the north wall of the building.

Two black slate switchboards are placed along the south wall opposite the generators. One controls the engine-driven generators and the motor-generator set and the other controls the distribution of current to the various buildings. Electrical current is carried from the switchboard to Haddon Hall through lead-covered cables installed in tile embedded in concrete on the outside of the tunnel.

A 12-in. I-beam installed over each engine provides for overhauling work. The engine foundations are of reinforced concrete built on wood piling. All the engines are operated non-condensing and exhaust to a low-pressure header to supply steam for the heating system, hot water and feed-water heating. At the present time the steam pressure at the throttle is 125 lb. This will be increased to 140 lb. as soon as all the connecting piping has been changed. The pipes are covered with 1¼-in. 85 per cent magnesium. Shower baths, lockers and lavatories are provided on this floor for the use of the employees. The contents of any pipe can be determined readily by a system of pipe coloring which has been adopted throughout the building. Cold-water pipes are painted yellow, hot-water pipes brown, high-pressure steam pipes blue, and low-pressure steam pipes pink. All brine pipes are painted black.

The second floor is designed for workshops and ash-handling apparatus. A fireproof wall separates the ash-handling section, approximately 9x36 ft. from the shops. A 10x4-ft. ash hopper about 5 ft. deep and equipped with a manually operated gate, is constructed under each boiler. Ashes are dumped from this hopper into a dump car of 2-cu.yd. capacity and rolled on a 36-in. gage track to the top of an ash receiving tank 9 ft. deep

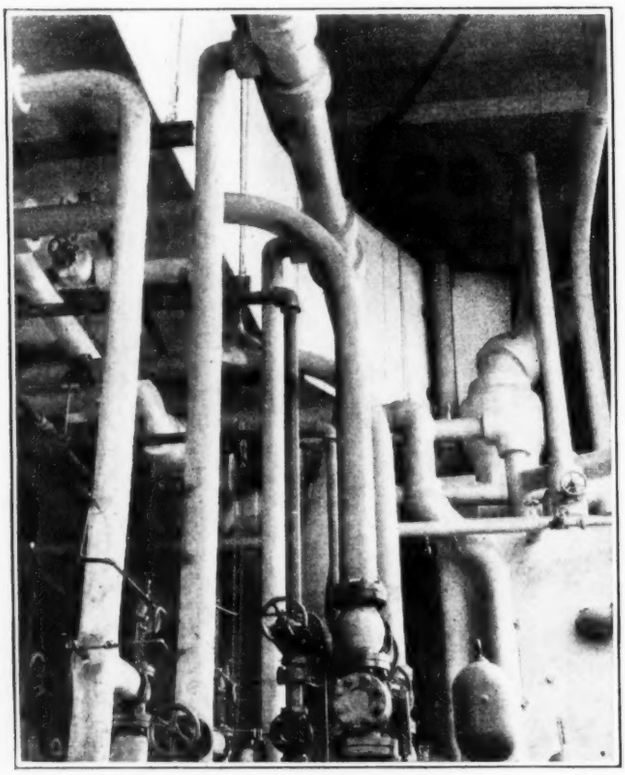


Fig. 10—Breeching 7-ft. square connected to the stack on the fourth floor

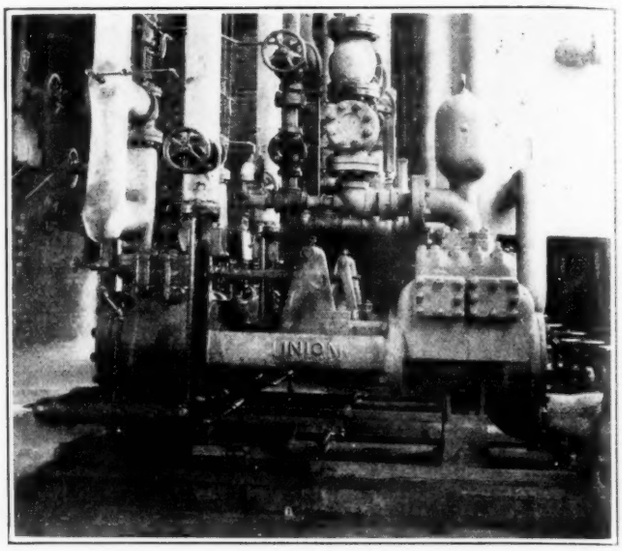


Fig. 11—Duplex boiler-feed water pumps. Feed water heater shown in the distance

on the outside of the building. It is provided with two manually operated gates. This tank, as well as the ash hopper, is made of corrosion-resisting cast-iron plates, mounted on angle framework and lined with tile to withstand abrasion.

Coal delivered to the plant by motor trucks is unloaded into a hopper which feeds into a bucket conveyor and is deposited into a coal bunker of 165 tons capacity, located above the boilers on the fourth floor. The conveyor is operated by a 20-hp. constant-speed motor, and is capable of handling 25 tons of No. 3 buckwheat anthracite per hour. Suitable stop and start switches are on the fourth floor, in the boiler room and outside of the building near the dump pit.

Two 5,000-sq.ft. stoker-fired boilers, designed for 200-lb. pressure, are installed on the third floor. The stoker speed and dampers are controlled automatically, and the motive power is supplied by a 1½-hp. variable-speed motor. Forced draft is automatically controlled by a 16,000-cu.ft. per min. blower with dual drive. Boiler makeup water is obtained from artesian wells by an air lift. This water, together with the plant condensate, is delivered to a feed-water heater of 100,000-lb. per hour capacity mounted in the rear of the boilers, which delivers water at an average temperature of 212 deg. The stoker and boiler settings are arranged to permit boiler operation at from 150 to 200 per cent of rating. At 150 per cent of rating the stack temperature is now averaging about 500 deg. F. and the CO_2 about 14 per cent.

A radial brick chimney 9 ft. inside diameter and 200 ft. high furnishes natural draft for both boilers. The base of the chimney is mounted on the fourth floor, and is supported by 40-in. I-beams and 20-in. square girders extending to the foundation piling. The inside is lined with refractory brick for 40 ft. above the base. A 7-ft. square sheet-iron breeching 40 ft. long connects both boilers with the chimney. This breeching is covered by 2-in. hard-finished magnesium blocks.

Two 14x8½x12-in. duplex steam-driven pumps supply feed water to the boilers, and flow meters, installed on the boilers, record the total steam delivered. The spacing of the boiler-room apparatus is liberal, and plenty of room has been allowed for general overhauling work.

The coal being burned is No. 3 buckwheat anthracite. A typical analysis of coal-pile samples is as follows: Fixed carbon, 78.05 per cent; volatile matter, 9 per cent; moisture, 1.3 per cent; sulphur, 0.65 per cent; ash, 11 per cent. Samples analyzed showed an average of 12,500 B.t.u. and the average daily coal consumption amounts to 33 tons.

The fourth floor is devoted to cold storage and refrigeration. Facilities are provided for the freezing of 168 cakes of ice, each weighing 300 lb., and untreated artesian well water, air-agitated, is used. A pneumatic crane of 1,000 lb. capacity and equipped with a 500-lb. motor-operated hoist lifts the cans of ice from the brine. An icehouse adjacent to the freezing equipment is capable of storing 168 cakes. Circulation of the brine

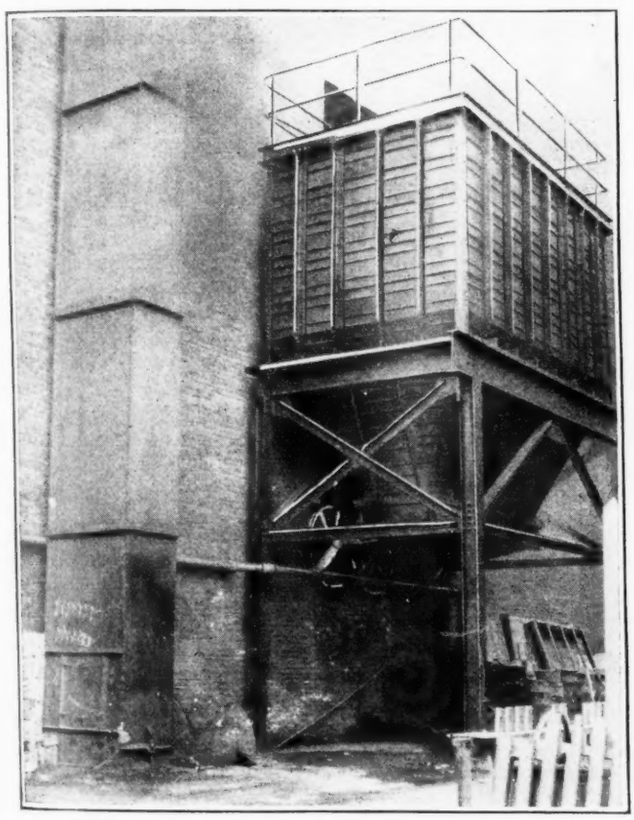


Fig. 12—View of outdoor ash tank and coal conveyor

is accomplished by four 75-g.p.m. pumps, each driven by a 10-hp. motor. Air agitation at a pressure of 2½ lb. is furnished by a 600-cu.ft. per min. blower driven by a 5-hp. motor. A 5-g.p.m. motor-driven pump is used for removing the liquid from the core of the cake. Ample cooling surface is supplied in the brine cooler to handle the maximum capacity of the plant.

One Otis elevator of 3,500-lb. capacity has been installed and is equipped with a car switch, push-button control, micro levelers, floor indicators and annunciator. A shaftway has also been erected to permit of an additional unit being installed at a future date.

Seven high-pressure steam traps varying in size from ¾-in. to 1½-in. are installed in various locations throughout the plant. In addition a 1¼-in. grease trap is installed on the exhaust line of each engine.

The building has been designed to permit an extension to be erected at a later date so that the ultimate capacity will be double the present.

The operation of the smaller plants was discontinued upon completion of the new plant. This centralization of power generation has not only effected a decided improvement in the plant efficiency, but has reduced the operating and maintenance expenses. Furthermore, the capacity has been increased and continuity of service assured.

The two old plants were operating with few recording instruments, so that complete comparative operating data cannot be obtained. It is stated that the new plant is operating with a boiler efficiency of about 80 per cent and that this is at least a 20-point improvement of the combined efficiencies of the old plants.

The increase in efficiency, and reduction of operating and maintenance expense, will no doubt show a saving at the end of the first year of operation.

Power is indebted to the Stewart A. Jellett Co., Engineers, Philadelphia, Pa., who designed the entire building and plant as well as the original plants of both hotels, and the management of the Chalfonte-Haddon Hall Hotels for the information contained in this article.

What Do You Know?

ENGINEERS possess either a superiority or an inferiority complex. If one possesses the first, he assumes to know a lot of which, in fact, he is absolutely ignorant. If affected with an inferiority complex, he goes through life with a sneaking feeling that his knowledge in any given subject is woefully vague. The ten questions listed below are for the purpose of curing you, no matter which complex you are cuddling. If you can answer all ten, your inferiority complex has no foundation, and if you fail, then that superiority complex you may have been displaying should be destroyed. The correct answers are given on page 833.

Ques. 1—How high above the tubes of a tubular boiler should the lower gage cock of the water column be placed?

Ques. 2—Will a given amount of radiation transmit more heat from 150-lb. or from 10-lb. steam?

Ques. 3—What is the Trent Process?

Ques. 4—Name three fluids used for refrigerating media, other than ammonia.

Ques. 5—After the piston of an oil engine has moved on its power stroke, is there a film of lubricating oil on the upper part of the cylinder walls, uncovered as the piston advances?

Ques. 6—Who built the largest hot-air engine, and where was it installed?

Ques. 7—Why doesn't compressed air issuing from a nozzle frost, as in the case of air exhausting from an air engine?

Ques. 8—With a diameter of, say, 10 ft. and a given r.p.m., is the likelihood of an engine flywheel exploding increased if the wheel is made wider in face with no other change in dimensions?

Ques. 9—Roughly, how many pounds of condensing water is required to condense one pound of steam after it has passed through a turbine and has entered the condenser, at 29-in. vacuum; that is, at 1 in. of mercury absolute pressure?

Ques. 10—Which crosshead shoe wears on an engine running over?

Another "Largest" Turbine

One Hundred Thousand Kilowatt Westinghouse Compound Unit for the Crawford Avenue Station in Chicago

THE Commonwealth Edison Company, of Chicago, Illinois, recently placed with the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company, an order for a 100,000-kw. steam turbine-generator unit and the necessary condensing equipment.

The new unit is to be installed in the Crawford Avenue Station, which will then have a total of 424,000 kw. capacity in six turbines. Some three years ago this station was started with three units from 50,000 to 60,000 kw. capacity. Subsequently, a unit of 75,000 kw. and one of 88,000 kw. were installed.

The new installation is of more than ordinary interest, especially the condensing equipment, owing to its unique design. The turbine is a three-cylinder unit of which the high-pressure element drives a 45,000-kw. main generator and a 4,000-kw. house generator, while the intermediate-pressure and low-pressure turbines, coupled in tandem, drive a 55,000-kw. main generator. Direct-connected exciters are provided for all generators. Both elements of the unit will operate at 1,800 r.p.m.

The combined rating of the two main generators is 117,000 kva., 100,000 kw., 85 per cent power factor, producing three-phase 60-cycle current at a potential of 12,800 volts. The house generator is rated at 5,720 kva., 4,000 kw., 70 per cent power factor and produces three-phase, 60-cycle current with an operating voltage of 2,300.

Steam will be supplied to the throttle at 550 lb. gage pressure with 725 deg. F. total temperature, and will pass into the condenser at a pressure of one inch of mercury absolute. The exhaust steam from the high-pressure turbine passes through a steam-heated reheater, raising its temperature to 500 deg. F. before entering the intermediate-pressure turbine. It is possible to heat all the feed water required for the unit by means of steam extracted from four stages of the combined unit.

The disposition of the enormous volume of exhaust steam discharged from the turbines presented a difficult problem in designing the unit. This was solved by resorting to the divided flow, or "triple flow" principle, by means of which the steam flow is divided among three

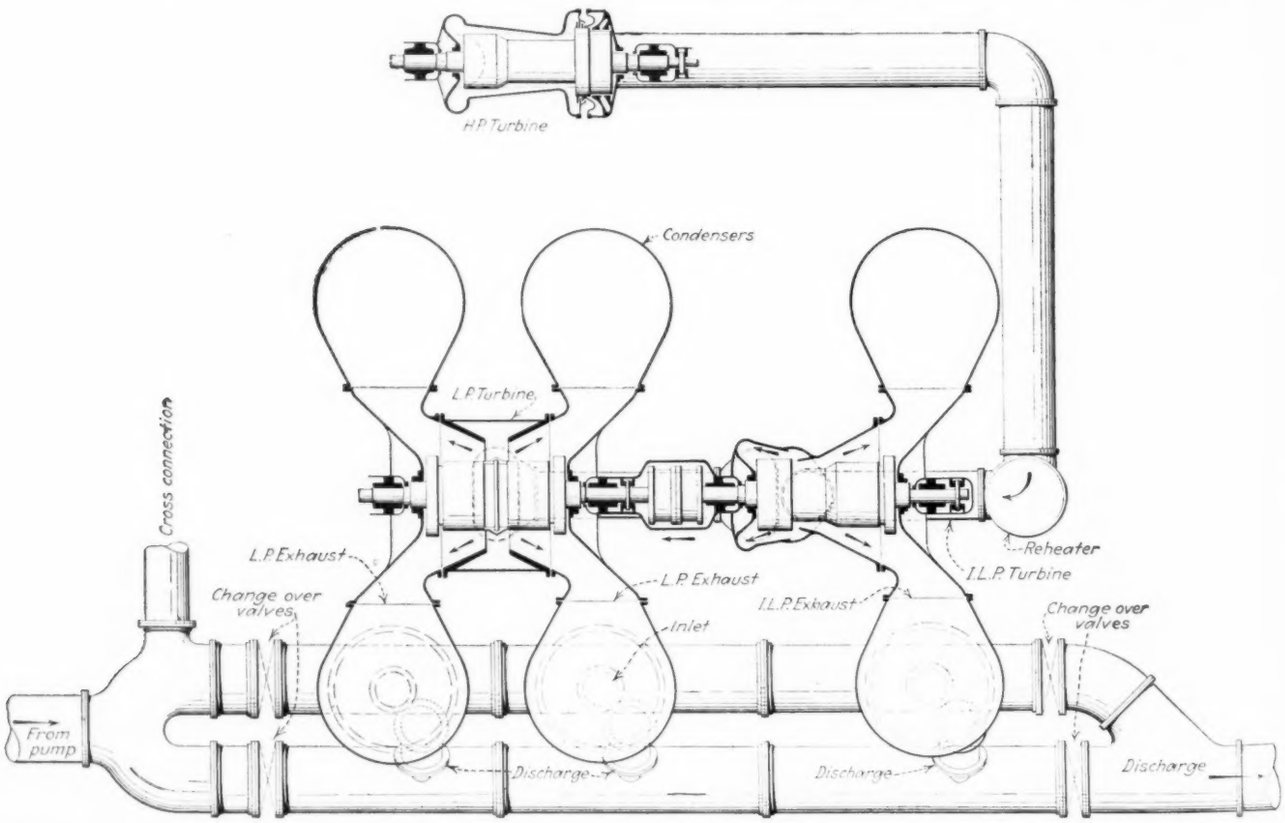


Fig. 1—The compound turbine makes possible three low-pressure wheels, and the vertical condenser lends itself to a double exhaust from each of these

The circulating-water piping shown for three of the condensers is duplicated for the other three.

exhaust openings. All the steam enters the high-pressure turbine and passes thence to a steam-operated reheater. From the reheater it passes into the intermediate-pressure turbine, which is of the double-flow design. In the intermediate-pressure turbine approximately one-third of the total steam passes through sufficient rows of reaction blading so that it leaves at the final exhaust pressure. The remainder passes through a smaller number of stages and is then carried through a receiver pipe to a double-flow low-pressure element, where the expansion is completed. Each of the three exhaust openings is subdivided and is served by two

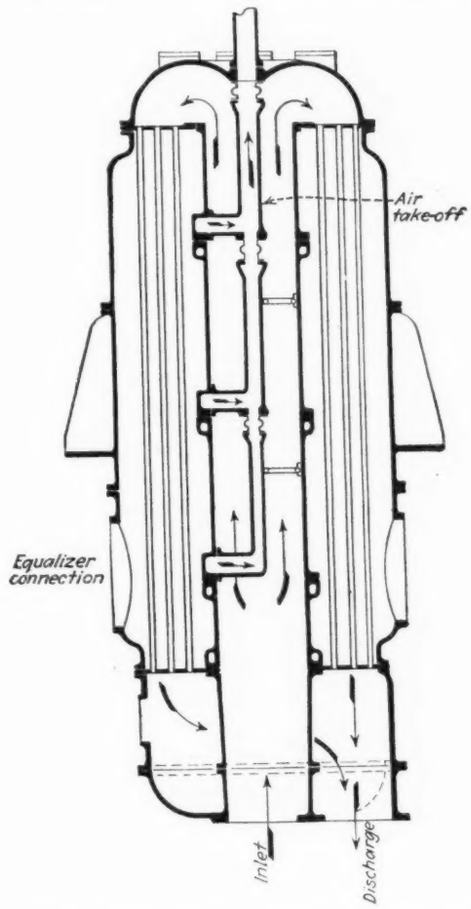


Fig. 2—The design of the vertical surface condensers provides for reversal of water flow for clearing tubes and tube sheets of debris

radial-flow, single-pass vertical surface condensers, each having 15,000 sq.ft. of condensing surface.

The six condenser units will condense approximately 730,000 lb. of steam per hour. Equalizer pipes are provided so that the steam spaces of all condensers on one side of the turbine are interconnected.

An interesting and valuable feature of the condenser design is the arrangement by means of which the circulating-water inlet and discharge openings are both in the bottom water-box, although the condensers are of the single-pass type. This is made possible by the use of a 36-in. diameter internal circulating pipe, which carries the incoming cold circulating water to the top of the condenser before it enters the tube nest, and through which the air offtake pipe is carried, thus insuring the maximum degree of cooling of the uncondensed gas before it is discharged from the top of the condenser. Change-over valves are provided in the circulating system (illustrated in Fig. 1) by means of which the direction of flow through either bank of condensers may be changed at suitable intervals, for a sufficient time to dislodge refuse or vegetable matter that may collect at the inlet ends of the tubes. These are the first single-pass condensers having these features to be installed in this country.

The condenser auxiliaries include two 95,000 g.p.m. motor-driven circulating pumps, two banks of three-stage air ejectors with surface inter- and after-condensers, and three two-stage condensate pumps. These circulating pumps have the largest capacity the company has ever furnished with condensing equipment.

To compensate for the refrigerating action of the lower tube sheet, two reheating hotwells, of the jet type, are furnished. The condensate will pass through these hotwells and have its temperature raised by means of low-pressure steam from the exhaust casing of the turbine.

Answers to What Do You Know*

Ans. 1—The lower cock should be 2 in. above the top of the top row of tubes, measured from the high end of the boiler.

Ans. 2—Since the temperature difference between the steam and room is greater with 150-lb. steam, more heat will be transmitted per square foot of radiation. This may not hold when the low-pressure steam is from the exhaust of an engine, as the pulsations may set up a wiping action and so decrease the film resistance on the radiator interior surface.

Ans. 3—To remove ash from coal, the latter, after being finely ground, is mixed with oil. The ash will settle to the bottom and a fuel mixture of coal and oil remains.

Ans. 4—Carbon dioxide, butane, propane, ethyl chloride, air, water, sulphur dioxide, etc.

Ans. 5—As the temperature within the cylinder during the combustion period is far above the burning point of oil, it is evident that the oil film is burnt at each power stroke.

Ans. 6—John Ericsson built the largest hot-air engines, four of which were installed in the 2,200-ton ship Ericsson in 1855.

Ans. 7—Because the energy of the air is not reduced by making it do work, and for a gas like air the energy is almost exactly proportional to the temperature. In the engine energy is removed and the temperature goes down. In a simple blowing jet the intrinsic energy is converted into kinetic energy, but this is all returned to intrinsic energy again as the jet slows down. Right in the center of the high-speed jet, the temperature is low.

Ans. 8—No. The weight increases with the face, but the total resistance to fracture increases with the face increase.

Ans. 9—With a 20-deg. water temperature rise, approximately 48 lb. are needed, and with a 10-deg. rise, 95 lb.

Ans. 10—The force along a connecting rod can be resolved into two components, that due to the steam acting on the piston and that due to the reaction at the guides. If the engine runs over, this latter causes wear of the lower crosshead shoe.

*The questions will be found on page 831.

Catching Pulverized Coal Ash at the Trenton Channel Plant

By Cottrell Electrical Precipitation

By H. M. PIER* and A. N. CROWDER*

THE disposition of pulverized-coal ash is a live topic in the power-plant field, and this detailed account of one solution that has proved successful should be studied by every engineer who is burning pulverized coal or considering doing so. It may not be necessary in all situations to make an effort to avoid blowing the ash up the stack, but communities in increasing numbers are demanding that their industries do all in their power to avoid polluting the atmosphere. This article describes a successful effort in this direction.

ONE of the problems in the use of powdered coal is the treatment of the stack gas for the removal of the ash particles carried in suspension in the gas. A large proportion of them pass out the stack unless equipment is installed to remove them from the gas.

Whether or not the discharge to atmosphere of the untreated ash-laden gases constitutes a public nuisance is a much argued question. It depends, primarily, on the situation of the plant with respect to surrounding residential or business communities, on the direction of the prevailing winds, and on the general policy of the neighborhood toward the air pollution question. The trend of the times is toward more rigid control of industry with respect to atmospheric pollution, as evidenced by the increasing numbers and activities of smoke inspectors in the large cities and in the growing tendency to enforce smoke ordinances.

In the design of the Trenton Channel plant, the Detroit Edison Co. engineers desired to install equipment to eliminate the possibility of nuisance. They selected the Cottrell Process as offering the most promise, and equipped two stacks. The original units were inadequate and difficult to maintain, but they did indicate that the process would solve the problem if it could be kept in continuous operation. A small precipitator of improved design, later referred to as the "pilot" unit, was installed and tested. The design thus developed was adopted, and the plant is being fully equipped with eight precipitator units serving the four stacks discharging gas from eleven boilers.

As shown in Fig. 1, the gas from three boilers enters one stack, passing through two precipitators, each treating the gas from one and one-half boilers. Before reaching the Cottrells the gas has passed through economizers, so that its temperature in the precipitator is about 350 deg. to 400 deg. F.

The boilers are of the Stirling type W, each having approximately 29,000 sq.ft. of heating surface. They are operated over a range from 200 to 400 per cent of rating, the normal operation being at 280 to 300 per cent. Details on other equipment at this station are given in an article in *Power*, May 27, 1924, page 848.

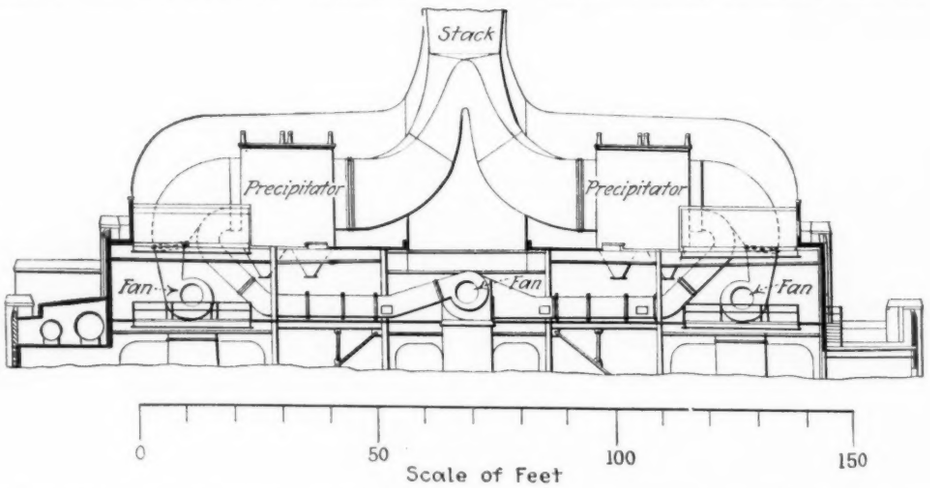


Fig. 1—The precipitators are built on the roof, on either side of the stacks. Three induced-draft fans discharge into each pair of precipitators

Each stack discharges from 900,000 to 1,200,000 lb. of gas per hour when the boilers are operated at 250 to 300 per cent of rating and about 1,800,000 lb. per hour with the boilers at 400 per cent of rating. Expressed in volume, this gives a total of from 18,000,000 to 36,000,000 cu.ft. of gas per hour per stack.

Carried in a suspension in this volume of gas is the ash from the burning of the powdered coal. From 60 to 90 per cent of the total ash is estimated to be sus-

*The Research Corporation, Chicago and New York.

pended in the gas after the economizers, depending on the rate at which the boilers are operated. Tests made on the gas at the precipitator inlet show an average dust concentration of 2.3 grains per cubic foot (gas calculated to 29.92 in. of mercury at 32 deg. F.). An examination of the screen test given in the table shows that 98 per cent of this dust passes through 80-mesh and something more than 80 per cent through 325-mesh. No data are available as to the size of the smallest particles, but it is probable that the dust from portland cement kilns is comparable, in which case the size of the smallest particles is about 0.0002 in. Each cubic foot of gas has in suspension about 3.5 million particles, or a total of nearly 1½ trillion particles per minute per stack. Each one of this multitude of particles is a separate entity carried along in the gas stream. Each individual particle must be acted upon independently and removed from the gas stream by itself.

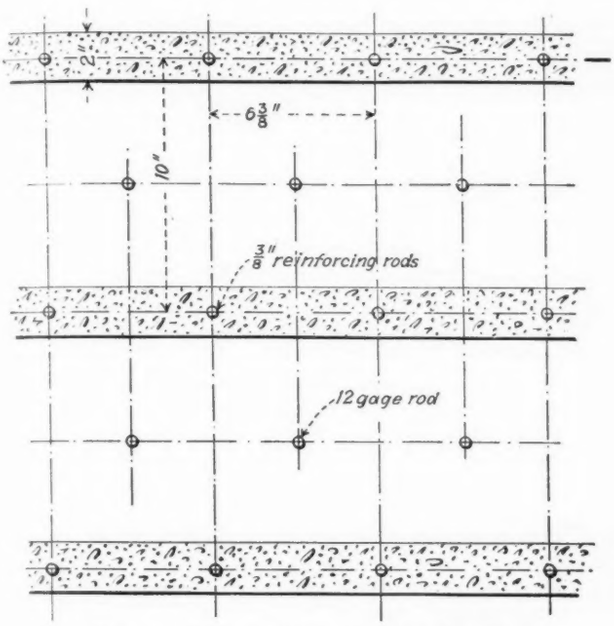


Fig. 2—Plan section showing details of precipitator construction

The reinforcing rods are carefully centered in the concrete plates. The negative wire electrodes hang between the plates from an insulated top suspension, with a 20-lb. weight on the end of each wire to hold it taut. Guides and stiffeners prevent swinging. These high-tension electrodes are insulated from the plates and from the casing, both of which are grounded.

What the Precipitator Is

So much has appeared in the technical literature pertaining to the theory of the Cottrell Process that a detailed discussion of it will not be given here other than to say that under proper conditions any mechanically carried particles can be removed from air or gas by the correct use of a high-voltage *unidirectional* electrical current, owing to the fact that the gas so treated becomes ionized and each dust particle receives an electrostatic charge which causes the particles to migrate toward the grounded one of the two electrodes between which the electrical field is maintained, and finally causes a precipitation of the particle on the grounded or collecting electrode.

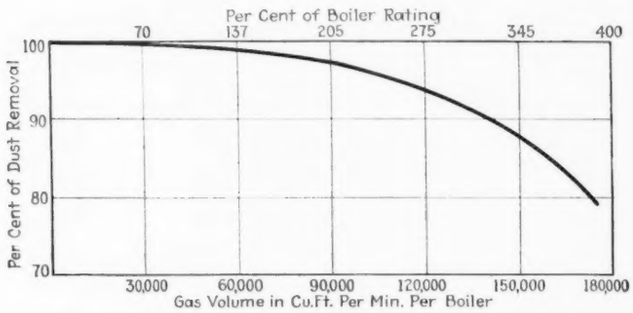


Fig. 4—Efficiency curve for pilot precipitator

In any Cottrell installation there are two elements—the precipitator itself through which the gas passes for treatment, and the electrical equipment for producing high-voltage unidirectional current.

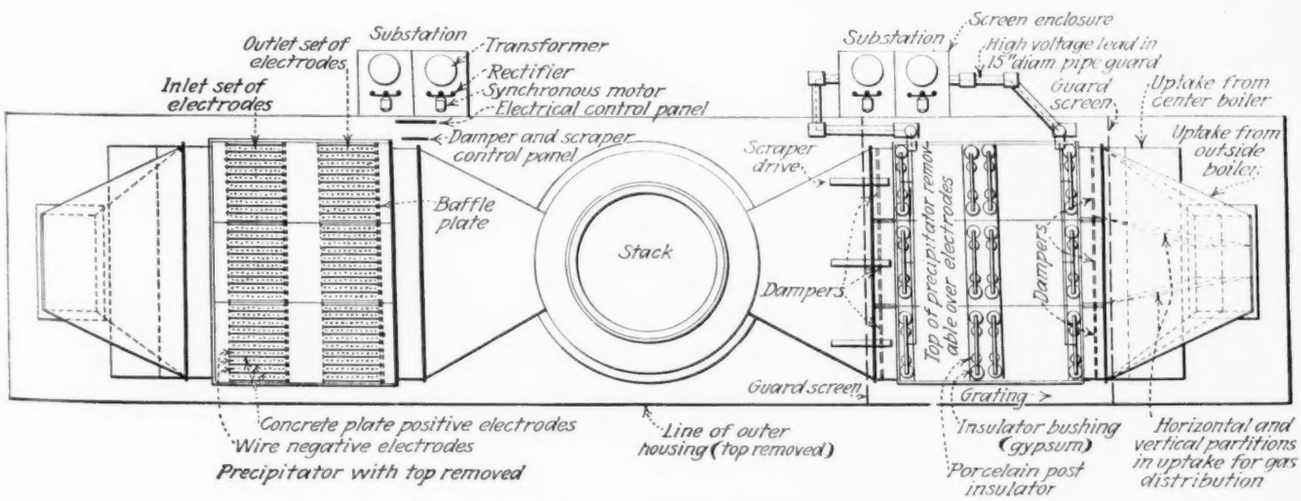


Fig. 3—Plan showing relation of precipitators, electrical equipment, stacks, etc.

The precipitators now in use are designated as "graded resistance, concrete plate, horizontal flow type."

The shell of each precipitator consists of ¼-in. steel plate riveted and welded so as to be practically gas-tight. Within each unit are suspended vertically, concrete collecting electrodes parallel with each other, as shown in Fig. 2.

A unit of electrical equipment consists of a 25-kva.

transformer which steps up a single phase of the 220-volt power supply to 75,000 volts with low-voltage taps for adjustment; a motor-driven mechanical rectifier to convert the high-voltage alternating current to unidirectional current supplied to the precipitator through a negative potential high-voltage line, with the positive side grounded. There are two electrical units for each precipitator, with switching arrangements providing ample flexibility for repairs and cleaning. A switchboard with electrical instruments and controls, and adjacent panel boards for compressed-air valve control and damper interlocks enable the attendant to operate the entire unit from a central point.

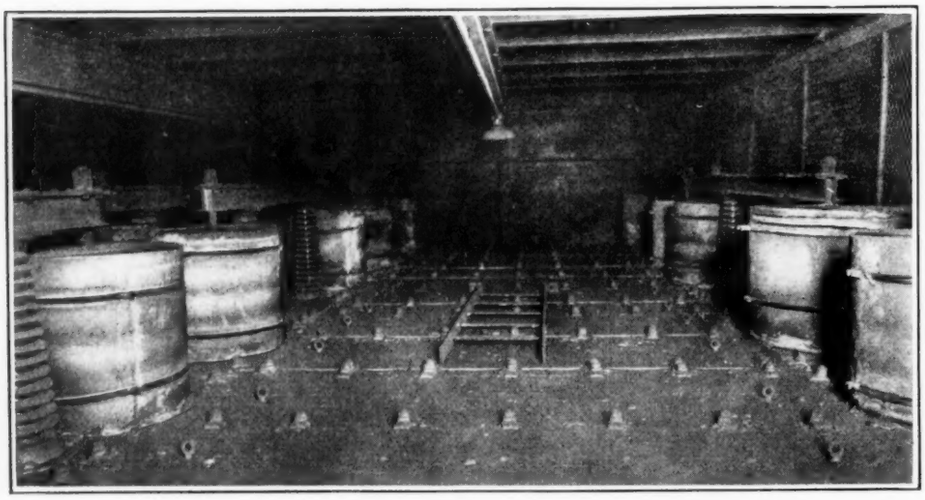


Fig. 5—The electrode suspension system for the negative wires

The insulating system suspends the frames carrying the wires through suspension insulators passing through gypsum bushings to prevent the escape of gas. The outer housing protects the insulators from the weather and keeps them warm and dry.

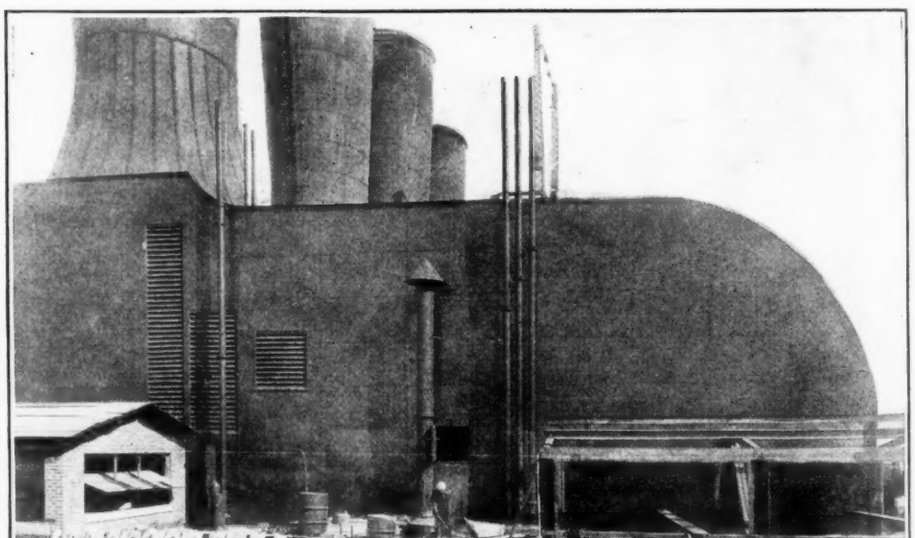


Fig. 6—The housing covers and protects the entire unit

The housing is grounded, so that workmen cannot make contact with the high-tension elements. Air enters the louvers in the housing and is drawn into the top of the boiler room by ventilating fans. This prevents excessive heating of the precipitator structure and keeps the upper portion of the boiler room warm in winter, avoiding condensation in the pulverized-coal conveying piping.

Precipitation

One of the primary factors in the design of any dust-catching device is the speed at which the gas passes through the elements. By experiment with test precipitators working under similar conditions and observation on the previously installed precipitators at Trenton Channel, it was found that in this case the maximum velocity of treatment for effective clean-up should not exceed 12 or 13 ft. per sec. under actual operating conditions. Of course the lower the velocity, other conditions remaining the same, the greater the clean-up or efficiency. Therefore, the new precipitators were designed of such an effective cross-sectional area that the maximum velocity would not exceed 13 ft. per sec. at 400 per cent of boiler rating.

The volume of gas produced at this and lower ratings was accurately determined by Pitot tube, calculation from combustion data and measurement by induced-draft fan displacement. These methods did not check, of course, but a good average was obtained. This average is 89,000 cu.ft. per min. per boiler at 200 per cent of rating and 175,000 at 400 per cent, actual gas volume at 350 deg. F.

Since each precipitator is to treat the gas from one and one-half boilers, the gas passing at 400 per cent of rating will be 262,500 cu.ft. per min., or 4,375 cu.ft. per sec. Dividing this figure by the velocity of treatment (13 ft. per sec.) gives an effective cross-sectional area of 336 sq.ft. In order to fit the space available, this area is made up of 30 ducts each 8 in. wide and 17 ft. high effective. These are divided into groups or units of 10 ducts by steel partition plates so that one

unit may be closed off by suitable dampers and cleaned while the gas passes through the other two units.

The length of treatment is another design factor, and in this case it was limited by space between the outside edge of the roof and the stack breeching. Allowing for flue connections, dampers, etc., the effective horizontal length of each duct is 12 ft. 10 in. This length of duct is obtained by two electrodes in series or tandem. Each concrete electrode plate is 17 ft. 11 in. high, 6 ft. 5 in. long (horizontal) and 2 in. thick.

Allowing for high-voltage framework and space for dampers, this gives a precipitator of three units 26 ft. 1 in. wide, 25 ft. long in the direction of gas flow and 30 ft. 6 in. high including ash hoppers and insulators on top. See Fig. 3.

Since the efficiency of the precipitator depends largely on the velocity and therefore the size with a given volume of gas, there must be an economical point where volume (boiler rating) and efficiency of clean-up will balance. It was therefore decided to design these precipitators for a clean-up of at least 90 per cent at normal boiler rating of 280 per cent and at least 70 per cent at the maximum of 400 per cent of boiler rating.

As the gas passes through the field maintained between the positive grounded concrete electrodes and the negative insulated discharge electrodes, it is ionized and the dust is precipitated on the concrete electrodes. The bulk of the dust falls from the concrete plates when the deposit has reached the necessary thickness to fall of its own weight. In order to provide a means, however, to dislodge the dust from the plates, should it be necessary, chain scrapers operated by a common air cylinder are provided.

The dust drops into the hopper at the bottom, from which it flows through pipes into sluicing troughs in the basement of the boiler room.

Multivane dampers interlocked and operated by air, placed at the inlet and outlet of each unit, permit shutting off any unit when desired, and, together with the partitions and deflectors in the inlet flue, control the distribution of gas flow through the apparatus.

CHARACTERISTICS OF ASH DUST FROM BOILER NO. 2
NOVEMER 25, 1926

	Per Cent by Weight		
	Magnetic Portion	Non-Magnetic Portion	Weighted Average
Combustible matter	6.4	11.0	9.4
SiO_2	41.9	46.5	44.9
Al_2O_3	17.1	22.5	20.7
Fe_3O_4	35.3	...	12.0
Fe_2O_3	...	8.6	5.7
CaO	4.2	5.4	5.0
SO_4	3.2	3.0	3.1
MgO	1.6	1.3	1.4
P_2O_5	0.2	0.2	0.2

MAGNETIC PORTION 34 PER CENT BY WEIGHT
NON-MAGNETIC PORTION 66 PER CENT BY WEIGHT

Mesh of Sieve	Per Cent Retained	Per Cent Passed Through
80	1.7	98.3
100	2.0	98.0
150	4.0	96.0
200	9.0	91.0
325	18.5	81.5

The collecting electrodes are made of a relatively poor electrical conducting material, and the electrical grounding is so placed with respect to the wire discharge electrodes that the maximum amount of resistance is in series with the minimum air gap and the minimum amount of resistance is in series with the maximum air gap. This feature has given this type its name of "graded resistance precipitator."

Readers familiar with electrical precipitation will recall that heretofore the collecting electrodes have been entirely metallic, either plates or pipes, and have been, therefore, good electrical conductors. This type is entirely suitable for some dusts, but on a material like the ash precipitated at Trenton Channel, it was not satisfactory.

With the "graded resistance" precipitator, on the other hand, because of its high internal resistance, the operation of the precipitator is normal in spite of the accumulation of dust on the plates. The dust can be allowed to build up on the plates to a thickness that will cause it to slide off of its own weight. It is conceivable, of course, that some dusts might build up on the plates to such a thickness as to cause a short-circuiting between electrodes, and so the chain scrapers are installed as a safeguard. As a test the first, or pilot, concrete plate unit at Trenton Channel was operated continuously for 21 days, with no scraping and with slight lowering of efficiency. In order, however, to have an operating routine the scrapers are operated once every shift.

Efficiency Test

The first consideration, naturally is the efficiency of dust precipitation. A long series of tests was conducted on the first or pilot concrete-plate precipitator at Trenton Channel, under various boiler conditions, and dust determinations were made by sampling the gas simultaneously at the inlet and outlet of the precipitator. The scheme of sampling used was the standard Brady filter method. From the results thus determined the curve of Fig. 4 shows the efficiency of the apparatus at varying boiler ratings.

It will be seen that at 280 per cent of boiler rating (normal operation) the efficiency is slightly under 95 per cent, while at 400 per cent of rating, which is the peak condition, the efficiency is slightly under 80 per cent. A test with only the first plate of the precipitator active (the second half being electrically disconnected) showed an efficiency of 85 per cent with boiler at 320 per cent rating as compared with 92 per cent with both plates active.

The normal operating voltage, by transformer ratio, was found to be 50,000 to 52,000. A test at 45,000 volts with the boiler at 280 per cent rating showed an efficiency of 90 per cent as compared with 94 per cent with the normal voltage applied.

The average dust concentration in the inlet gas was found to be 2.31 grains per cubic foot (calculated to 29.92 in. of mercury and 60 deg. F.). The concentration varies from 4.45 grains per cubic foot to 1.30. In the same manner the quantity of dust collected varies over quite a range, depending on the operation of the boilers. A figure of fourteen tons per day per boiler seems to be a fair average.

The back pressure or resistance to gas flow is practically nil, ranging from 0.08 to 0.17 in. of water, depending on the volume of gas passing.

In the preparation of this article due acknowledgment is given to the Detroit Edison organization for their assistance in preparation of drawings, photographs and data used in the article.

A material share of the credit for developing the application of the present type of Cottrell Precipitator to the powdered-fuel-ash field is due to the Detroit Edison Company for their hearty co-operation and assistance in the work, and grateful acknowledgment is here made for such service.

Experiences with the Benson Steam Generator

By G. H. GLEICHMANN

FOR some time the Siemens-Schuckert Company has been operating its first experimental installation of the Benson System. Test results and experience obtained from over 2,000 hours of its operation form the basis of this article. A description of the Benson system for generating steam at 3,200 lb. was published in *Power*, May 22 and 29, 1923.

THE Siemens-Schuckert Company has installed in its power plant in Berlin-Siemenstadt an experimental Benson high-pressure system capable of generating between 10,000 and 22,000 lb. of steam per hour at a pressure of 3,200 lb. The steam is then throttled to 1,420 lb. pressure and reheated to 752 deg. F. before being delivered to a back-pressure turbine.

The original Benson system, as installed in England, consists of five continuous helical coils encircling the interior of the generator. Water at 3,200 lb. pressure is fed to the bottom of the coils, while the gases of combustion pass downward over them. As the water rises, its temperature continually increases until the critical temperature of 706 deg. F. is reached. At this temperature the water changes instantly to steam having the same specific volume and the same total heat as the water. This transformation takes place without boiling or ebullition. Table I shows how the volume of one pound of water increases as its temperature is

TABLE I—SPECIFIC VOLUME OF WATER AND SATURATED STEAM

Temperature, Deg. F.	Cubic Feet per Pound—Water	Cubic Feet per Pound—Saturated Steam
400	0.0187	1.872
500	0.0206	0.69
600	0.024	0.28
650	0.027	0.18
670	0.028	0.14
706	0.050	0.05

raised and will serve to indicate more clearly what happens at the critical temperature.

Thermally, it is immaterial whether steam be generated at the lower pressure or generated at the critical point and its pressure reduced by throttling. The advantage of the Benson system is a practical one, permitting the construction of a generator with small tubes arranged in continuous coils and without large disengaging drums. This is important since at high pressures below the critical, difficulty is experienced from priming, and larger tubes and drums are required.

As the high-pressure surface is of heavy construction and more expensive to build, the Siemens-Schuckert Company felt it desirable to locate it so as to absorb at least a part of the radiant furnace heat, which is where the expensive surface will be utilized to the greatest extent. Accordingly, a 3,280-sq.ft. horizontal water-tube boiler operated at 185 lb. pressure was raised as high as the building would permit and connected with a new high-pressure section installed directly beneath it, as shown in Fig. 1. Oil burners were selected because of their great flexibility in firing and because the construction made it impractical to install grates or stokers. The old boiler, used as an economizer, is able to heat the feed water to 356 deg. F. A high-pressure feed pump forces the water from the old boiler into the lower row of tubes in the high-pressure section, thereby preventing steam generation

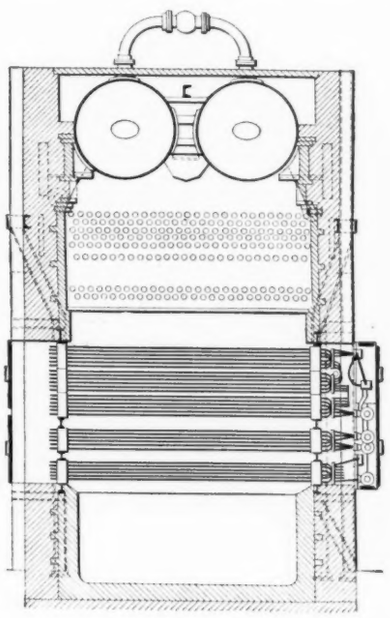


Fig. 1—Sectional elevation of Benson Steam Generator

in these tubes which are directly exposed to the radiant heat. This part of the boiler constitutes about one-fifth of the total heating surface. The water in these tubes, after being converted to steam, enters the upper part of the heating surface, where it is superheated to about 752 deg. F. The superheating surface contains approximately three-fifths of the total high-pressure heating surface. The steam at 3,200 lb. pressure is next throttled to 1,420 lb. with a corresponding temperature drop to 590 deg. F. It is then reheated to 752 deg. F. in the remaining middle section.

The high-pressure heating surface totals 2,329 sq.ft. It consists of parallel banks of bent tubes shown in Fig. 2, having an inside diameter of 0.788 in. and an outside diameter of 1.26 in. A continuous flow of water is maintained in the lower tubes, which becomes a steam flow in the upper tubes. Mixtures of steam and water do not circulate as in the ordinary boiler.

Some difficulty was experienced from unequal expansion due to poor heat distribution in the lower banks of tubes. Means were taken to obtain a fairly even

water and heat distribution, and the design gave no further trouble from this cause.

The feed water consists of 70 per cent condensate and 30 per cent of "Permutit" treated makeup water. The condensate is not entirely pure owing to condenser tube leakage. In spite of these adverse conditions no boiler scale could be detected. This absence of scale is attributed to the fact that steam bubbles do not form on the tube walls at the critical pressure. The solid impurities are deposited within the superheater in the form of mud. The remaining impurities are deposited in the piping, the turbine and the condenser. Examination of the turbine buckets after a considerable period of operation showed a scale deposit very similar to that found in boiler drums. Each of the parallel tube banks is equipped with a small blowoff valve, which may be opened under full pressure.

The boiler tubes and parts are made of a high-grade mild steel having an elastic limit not affected greatly by high temperatures. Expensive heat resisting alloys are necessary only in the superheater, in which the steam temperature may reach 932 deg. F. As the tubes could not be manufactured in the lengths required, it was necessary to resort to welding. Thermit lap-welded joints were employed with excellent results, and are preferable to electric welding because the latter builds up a thickness of metal on the inside surface of the joint, which cannot be cut away. The ends of the tubes are provided with screwed and welded flanges to connect them with headers located in the coolest part of the furnace. Either nickel or soft-iron gaskets are used. These joints gave leakage trouble at times when very sudden temperature changes occurred. Although these disappeared immediately after normal temperature conditions returned, it was decided to remedy this fault. The trouble disappeared when spring washers were placed in the joints, as shown in Fig. 4.

Fig. 2 (Right) — High-pressure tube bank

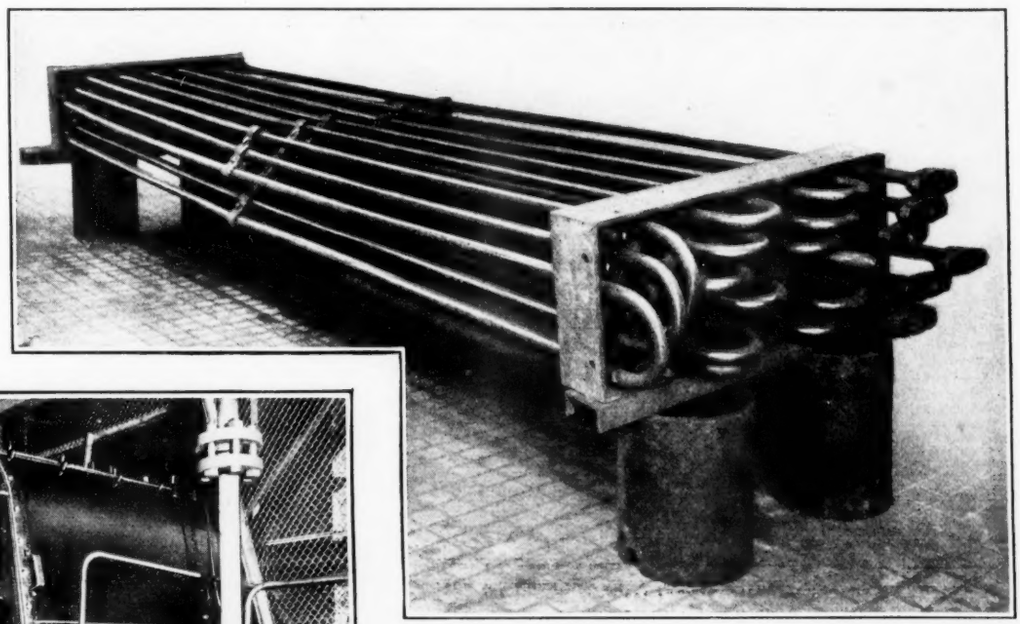
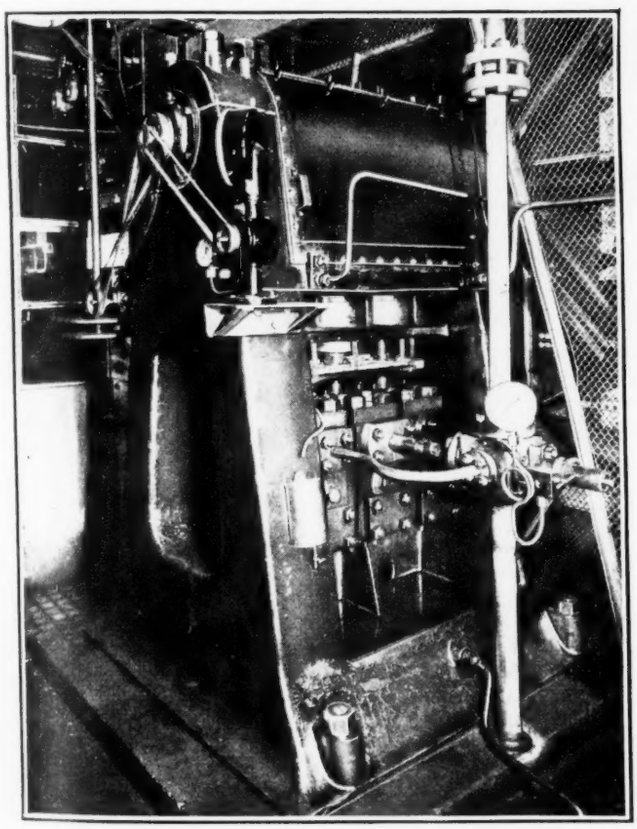


Fig. 3 (Below) — High-pressure three-plunger feed pump



The boiler valves, which have given no trouble, are partly made with cast-steel and partly with wrought-iron flanged bodies. The disks are made of stainless steel and metallic packing is used in the stuffing boxes. Even the valve which reduced the initial steam pressure of 3,200 lb. down to 1,420 lb., showed only slightly cut seating surfaces after 1,500 hours of operation, which is of little consequence, as the valve is never used as a shutoff. A special hard steel is now used for the seating surfaces of this valve for experimental purposes.

No water columns or gage glasses are used in the Benson boiler, as the height at which the water turns into steam, varies with the load. Venturi meters measure the feed water at 3,270 lb. and the steam flow at 1,420 lb.

The 1,420 lb. pressure is automatically held constant by a reducing valve equipped with a constant-pressure regulator. A hand throttle valve is installed as a spare. Weighted-lever safety valves are provided for both the 3,200-lb. and the 1,420-lb. pressure.

Fig. 3 shows the high-pressure, three-plunger feed pump for feeding water from the economizer (low-pressure section) into the high-pressure section of the boiler. This pump, driven by a direct-current motor, operates with a constant discharge pressure of 3,270 lb. It is of standard construction and of the type usually employed for hydraulic presses. The high tem-

perature of the feed water developed considerable trouble in the stuffing boxes and was remedied by the use of antimony-alloy liners. The original bronze valves were replaced with others made of stainless steel. A decrease in the volumetric efficiency with the load made it necessary to rebore the cylinders and to install larger plungers in order to secure the desired capacity.

Table II includes the observations made during several tests on the boiler at different ratings. No heat balance is computed, because the boiler was not designed for high efficiency. For the same reason no effort was made to determine the heating value of the tar-oil fuel used. Every engineer realizes that the efficiency of a boiler depends upon the furnace efficiency and the amount of heat that can be recovered from the flue gases. By installing a sufficiently large economizer and air-preheating surface, a boiler efficiency of 74 per cent can easily be increased to 85 per cent.

Calculations show that it is possible to build and install a Benson system at about the same cost as that for a standard boiler plant operating at 450 lb. pressure.

TABLE II—RESULTS OF TEST ON BENSON STEAM GENERATOR

Water evaporated, lb. per hr.	8,720	12,900	16,400	20,750
Temperature of feed water to low pressure boiler, deg. F.	68	71.6	73.4	71.6
Feed water to high-pressure feed pump				
Pressure, lb. per sq.in.	59.7	111	138	138
Temp., deg. F.	282	329	349	349
Feed water to high-pressure boiler				
Pressure, lb. per sq.in.	3,270	3,260	3,260	3,270
Temp., deg. F.	284	331	352	352
Steam condition before reducing valve				
Pressure, lb. per sq.in.	3,220	3,140	3,020	2,960
Temp., Deg. F.	738	738	734	717
Steam condition after reducing valve				
Pressure, lb. per sq.in.	1,450	1,450	1,472	1,510
Temp., deg. F.	592	590	592	588
Steam condition at reheater outlet				
Pressure, lb. per sq.in.	1,420	1,413	1,420	1,406
Temp., deg. F.	750	767	767	750
Power to drive high-pressure feed pump, kw	317	46.4	60.2	79.6
Fuel oil consumed, lb. per hr.	1,110	1,490	1,766	2,160
No. of burners operating	4	4	5	6
Fuel-oil pressure, lb. per sq.in.	78.2	128	107	127
Exit gas temp., deg. F.	374	415	482	532
Per cent CO_2 in flue gas	11.0	11.5	12.0	12.2

In making this comparison, the fact that the Benson boiler is not a standardized product but must be built to order, has been taken into account.

No expensive special equipment is required to build a Benson boiler, and the various high-pressure accessories are now available from some manufacturer, or because of their relatively small size, it would not be difficult to make them in any modern machine shop. When manufactured on a production basis, their cost would not be high. The price paid for the raw materials, tubes, etc., was also higher than would be the case if there was a small established market for these materials in the required sizes and lengths. Considerable savings in the initial cost are therefore quite probable.

Sensitive to Load Changes

The Benson system has been criticized on account of its high sensitiveness under sudden changes in load. In this connection it may be said that any boiler having a small water-storage space will show a drop in steam pressure when subjected to a sudden increase in load, with a constant furnace output. On the other hand, such a boiler will show an equally rapid restoration of the normal pressure when the furnace output is increased.

A good mechanical boiler-control functioning in conjunction with a flexible firing method will eliminate all objectionable pressure fluctuations. Under such conditions pulverized coal, gas and oil firing will be able to compensate for sudden large load fluctuations; underfeed stokers for moderate load changes, and natural-draft traveling-grate stokers for only slight load changes.

Explosion Hazard

The bursting of two tubes in the experimental boiler demonstrated that the explosion hazard is negligible. The rupture was accompanied by a hissing noise and the oil burners were extinguished. The fire was not blown out into the room, and the plant operation was not seriously interfered with.

A defective tube may be easily replaced. It is also possible to repair a ruptured tube by welding. There is no danger of a general tube burn-out because the steam and water issuing from a broken tube is a sufficient protection against overheating by the fire.

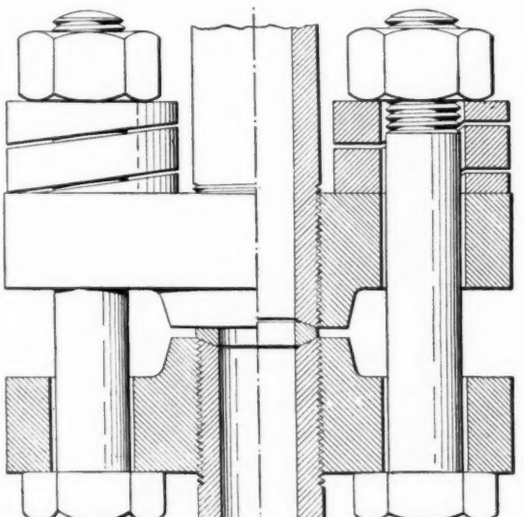


Fig. 4—Flange joint for 3,200 lb. pressure

The advantages of the Benson boiler may be summarized as follows:

The initial cost will be the same as that of a boiler generating at 500 lb., and less than the initial cost of a 1,200-lb. boiler.

There is no possibility of a dangerous explosion and tube ruptures are easily repaired.

Little time is required to raise the boiler to full steam pressure.

The experience with this installation has been so satisfactory that a Benson system is being installed in the power plant of the cable department of the Siemens & Halske Co. This installation will have a capacity of 66,100 lb. of steam per hour and will be fired by pulverized coal. It will furnish steam for a 3,000-kw. back-pressure turbine, exhausting to process apparatus. The installation is now nearing completion and tests will be made as soon as preliminary starting-up troubles have been corrected.

Plans are now being prepared for applying the Benson system of steam generation to marine practice and railway locomotives, as well as to the utilization of waste heat in connection with gas fired metallurgical processes.

Effect of Radiant Heat on Water-Cooled Furnace Walls

A Discussion of What Happens in the Water Screens, Water Walls and First Row of Boiler Tubes, the Velocities Attained and Probable Rates of Heat Absorption

By A. G. CHRISTIE
Professor of Mechanical Engineering, Johns Hopkins University

RADIANT heat in boiler furnaces has been given careful study by engineers only within the last few years. Recent designs of boilers and furnaces have heat-absorbing surfaces so arranged that full advantage can be taken of radiant heat transfer and more boiler-heating surface is now exposed to the fire than was the case in earlier boilers. The rate of heat transfer by radiant heat is assumed to vary as the difference between the fourth power of the furnace temperature and the fourth power of the boiler-tube temperature. The latter is usually taken as the temperature of the boiling water inside the tube. Obviously, small increases in furnace temperature greatly increase the rate of heat transfer. It is therefore desirable to employ every possible device and operating method that will insure the highest possible furnace temperatures.

Increase in furnace temperatures causes brickwork troubles. Refractories that were satisfactory with lower furnace temperatures, have frequently failed under higher temperatures, since the fusing point of the ash is often exceeded. The ash of certain coals, particularly when burned in pulverized form, causes brick walls to wash down rapidly with high furnace temperature due to the fluxing action of the liquid ash on the silica and alumina of the bricks. Water screens and water cooling of side walls were introduced to decrease this wastage of brick furnace walls, to cool the ashpit and to lower maintenance costs. All-metal side walls of the fin type or of the cast-iron refractory-faced block type were later introduced to eliminate brickwork inside the furnace, to stop the slagging of the ash and to permit the use of the highest possible furnace temperatures. The rapid absorption of radiant heat by these water-cooled walls tends to lower average furnace temperatures. The trend is toward high degrees of air preheating and low percentages of excess air, to secure the desired maximum furnace temperatures when water-cooled furnace walls are used. Recent designs of furnaces resemble a box with water-cooled sides, top and bottom.

Results at Cahokia

Much can still be learned about the action of radiant heat in the furnace itself, such as the radiation of carbon dioxide and water vapor, the screening effect of these gases, the character, depth and smoke-forming probabilities of the cool envelope around the outside of the flame due to the presence of the water-cooled walls, and the effects of turbulence. These will not be discussed in the present article, which will be devoted to certain phenomena in connection with the radiant heat absorbing surfaces themselves.

The latest data available on the rate of radiant heat transfer to boiler and water screen surfaces will be found in the 1924-25 Report on "Pulverized Fuel" issued by the Prime Movers Committee of the National Electric Light Association. Tests are reported on the water screens of one of the early types of pulverized-coal furnaces under an 18,010-sq.ft. B. & W. boiler at Cahokia Station, East St. Louis. This furnace had a water screen across the bottom above the ashpit, and on the rear wall of the furnace. Both side walls and the front wall were of air-cooled refractory brick. The fuel used was an Illinois coal having a fusing temperature of the ash of 2,000 deg. F. On this account the highest furnace temperatures could not be carried with the air-cooled walls because of the slagging and fluxing action of the liquid ash. Hence much higher rates of heat transfer than in these tests, may be expected where all-metal furnace walls permit the use of lower percentage of excess air and also the use of highly preheated air. Figs. 1 to 4 are reproduced here from the N.E.L.A. report.

The rate of radiant heat transfer, as indicated by these tests, varies between 40,000 and 75,000 B.t.u. per sq.ft. of exposed tube surface per hour. This heat transfer rate depends on the furnace temperature, the cleanliness of the tube surface inside and outside, the position of the exposed surface, the rating of the boiler and the luminosity of the flame. When the flames and hot gases sweep across or along the tube surfaces, transfer rates may be increased by the absorption of additional heat by convection. This occurred on some of the tubes tested. On the other hand, lower rates of heat transfer may be expected from water-cooled walls composed of refractory-faced metal blocks on account of the reflecting effect of the refractory.

The lowest row of tubes of a B. & W. type boiler which would form the roof of the furnace, will be considered first. Little information has been published on the rate of heat transfer in these tubes. Paul Bancel, in a paper on "Circulation in Horizontal Water-tube Boilers," Vol. 37, A.S.M.E., quotes F. Munzinger to the effect that for a furnace temperature of 2,500 deg. F. and a steam temperature of 400 deg. F., the rate of heat transfer per square foot of tube surface is about 100,000 B.t.u. per hour; for 2,750 deg. F. about 150,000 B.t.u. and for 3,000 deg. F. about 200,000 B.t.u. These figures would not be greatly modified with a modern boiler pressure of 425 lb. gage and 454 deg. F.

In view of the fact that these tubes have convection transfer as well as transfer by radiant heat, these figures seem logical from the Cahokia data. The transfer rate of 100,000 B.t.u. per sq.ft. will be assumed for the lowest row of tubes. It may also be assumed that the feed water is heated to boiling temperature in the boiler drum. This heat transfer provides the latent

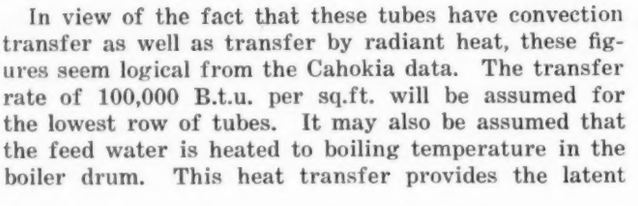


Fig. 1—Heat absorption of bottom and back water-screen tubes, Cahokia

heat to evaporate 129.8 lb. of water per square foot per hour at 425 lb. gage, or 2.165 lb. per square foot per minute, equivalent to the generation of 2.285 cu.ft. of steam per square foot per minute. If these tubes are 4 in. in diameter with 18 ft. of their length directly exposed, the total heat-absorbing surface will be 18.85 sq.ft. This, under the assumed conditions of heat absorption, would form 43.08 cu.ft. of steam per minute in each tube, or 0.718 cu.ft. per second. The cross-sectional area of such a tube will be about 0.07 sq.ft.

If it be assumed that the mixture leaving the upper end of the tube is 30 per cent water and 70 per cent steam, the velocity of the mixture would be 14.65 ft. per sec., while the water entering velocity would be about 4.6 ft. per sec. If a heat-absorption rate of 200,000 B.t.u. per sq.ft. per hour and a water-steam ratio of 25 per cent and 75 per cent leaving the tube were assumed, the leaving velocity would become 28.35 ft. per sec., while the entering water velocity would be 7.2 ft. per sec. Bancel, in the paper referred to, states that the velocity of the water entering these tubes is in the order of 5 ft. per sec.

If this steam and the steam from the upper tubes finds easy outlet through the vertical headers, no congestion or reduction of circulation will take place. When this outlet is restricted, there may be recirculation in some of the intermediate tubes above the bottom rows, and this is said to have occurred in certain boilers. When this occurs, there may be some tubes midway between, in which no circulation takes place and which may become steambound and dangerously overheated in consequence.

Superheating Improbable in Lower Row of Tubes

When steam is formed in the bottom tubes of the boiler, it rises to the upper portion of the tube which is away from the fire. If the steam were to separate from the water and glide along the upper portion of the tube, and if this section of the tube were also receiving heat at a rapid rate, one might conceive of this steam becoming superheated to some extent, owing to its low thermal conductivity to the water below it. However, this is unlikely to occur in the lower tubes of the boiler, as the upper surfaces are usually covered by fly ash and, not being exposed directly to radiant heat, do not absorb large amounts of heat, although the conduction of the metal in the heavier gage tubes now used, will tend to equalize the temperature in all parts of the tube. The turbulence inside the tube due to the steam bubbles passing up through the water would tend to break up the segregation of water and steam, to produce violent agitation and to prevent such superheating effects. Little difficulty has been experienced with the lower tubes of this type of boiler when clean, even with the highest furnace temperatures.

A relatively thin layer of scale inside the tube may retard heat flow into the water around the whole circumference and may permit the lower section of the tube, which is exposed to the intense radiant heat, to rise to temperatures at which the metal will begin to flow under the internal pressure of the boiler. This results in the well-known "bagging" and "burning" of boiler tubes. Absolute freedom from scale is a prime requisite for all boiler surfaces exposed to radiant heat absorption to prevent such tube failures. The necessity of pure condensate for boiler feed in modern plants, with distilled water from evaporators as makeup, cannot be overemphasized.

The horizontal water screen above the ashpit of the Cahokia boiler on which the test data were secured, consisted of 4-in. tubes placed on about 10½-in. centers

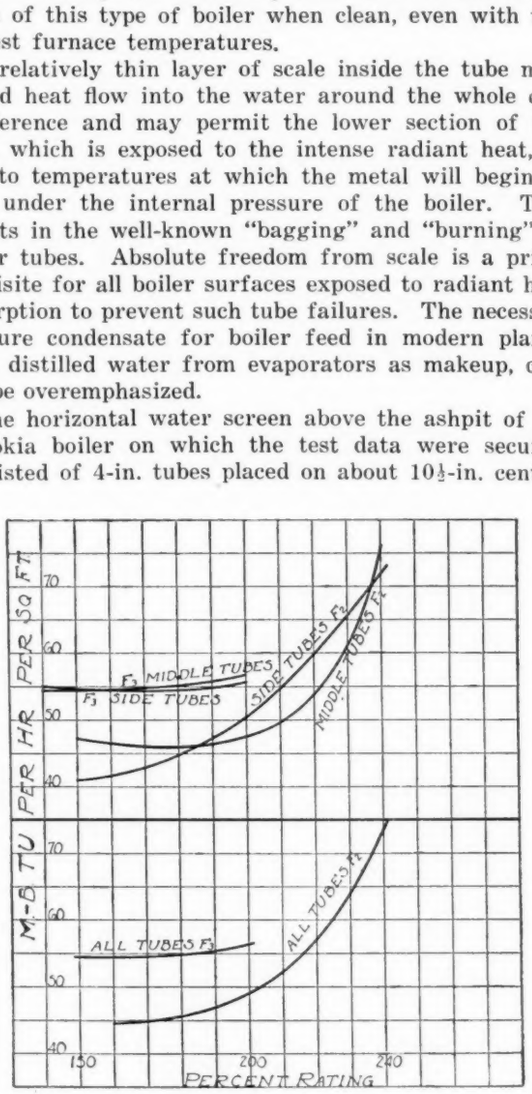


Fig. 2—Composite heat absorption of middle and side water-screen tubes and entire screen, Cahokia

with a length of about 20 ft. exposed in the furnace. These tubes discharged into a horizontal header at the rear of the boilers. A vertical screen on the rear wall connected to this same rear header and consisted of 4-in. tubes on the same 10½-in. centers with about 14 ft. of tube length exposed to radiant heat.

The curves in Figs. 2 and 3 show at 240 per cent rating that the composite heat absorption of all tubes is 75,000 B.t.u. per sq.ft. per hour, the average water velocity entering the screen is 3.68 ft. per sec. and

the average velocity of the mixture of water and steam leaving the screen is 13.5 ft. per sec. The proportion of the mixture leaving the screen under these conditions was approximately 72 per cent steam by volume and 28 per cent water. It will be noted that this is approximately the proportions of the mixture in the risers at this rating. Apparently, little separation of steam and water occurs in the upper headers of this screen. If the rear screen tubes had been longer or the furnace temperature higher, the leaving velocity of the mixture would have been higher and the percentage of steam in the mixture might have been increased.

Some furnaces have been constructed recently, with a single tube in the horizontal water screen above the ashpit, discharging through a special fitting into two vertical tubes in the rear wall. To analyze such construction, it was assumed that a 4-in. tube, No. 6 gage, with 20 ft. exposed, formed the horizontal water screen and this divided into two 4-in. tubes of the Murray fin type forming the rear wall, each with a length of 27 ft. exposed to the furnace. A boiler pressure of 425 lb. gage was assumed with a heat transfer of 75,000 B.t.u. per sq.ft. per hour. The Murray fin-tube wall was assumed with a projected area of 0.583 sq.ft. per running foot of length. It was further assumed that feed water entered the screen at boiling temperature so that latent heat only was transferred. The resulting figures showed that a mixture leaving the top of the rear screen with the same percentage as at Cahokia—that is, 72 per cent steam and 28 per cent water by volume—developed a velocity of 14.9 ft. per sec., while the necessary water

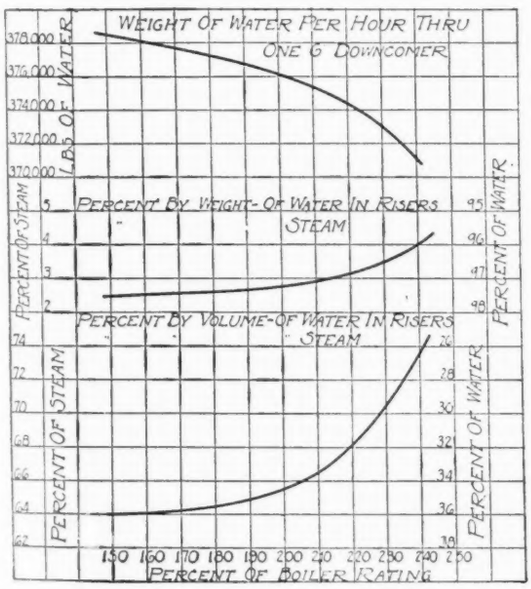

WEIGHT OF WATER PER HOUR THRU ONE 6 DOWNCOMER
LBS. OF WATER
PERCENT BY WEIGHT-OF WATER IN RISERS
STEAM
PERCENT BY VOLUME-OF WATER IN RISERS
STEAM
PERCENT OF STEAM
PERCENT OF WATER
150 160 170 180 190 200 210 220 230 240 250
PERCENT OF BOILER RATING

Fig. 3—Velocities in screen connections, Cahokia

velocity entering the horizontal screen was 8.7 ft. per sec. It will be evident that the water downcomers and water supply headers must be ample and must be carefully designed to insure water entering every tube at this higher velocity.

Proposal for Protecting Ashpits

The foregoing case is an extreme one and will probably be corrected by improvements in furnace design. The horizontal water screen as a protection to the ashpit has been satisfactory with some coals, but has its limitations with others. When vertical firing is used, the flames may be driven below these water screens at high loads. This leads to difficulties with slagging in the ashpit and with hot furnace bottoms. It is now proposed to protect ashpits with water-cooled cast-iron faced V-shaped bottoms built at a sharp angle. This construction will permit the use of the whole furnace

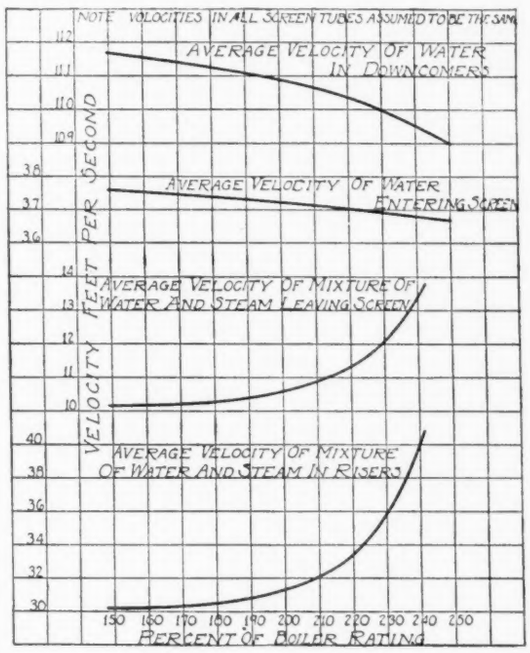

NOTE VELOCITIES IN ALL SCREEN TUBES ASSUMED TO BE THE SAME
AVERAGE VELOCITY OF WATER IN DOWNCOMERS
AVERAGE VELOCITY OF WATER ENTERING SCREEN
AVERAGE VELOCITY OF MIXTURE OF WATER AND STEAM LEAVING SCREEN
AVERAGE VELOCITY OF MIXTURE OF WATER AND STEAM IN RISERS
VELOCITY FEET PER SECOND
150 160 170 180 190 200 210 220 230 240 250
PERCENT OF BOILER RATING

Fig. 4—Weight of water and per cent water and steam flowing in water-screen connections, Cahokia

volume at high boiler ratings, and will minimize, if not entirely prevent, the slagging of the ash. These bottom sections could be provided with separate flow and return headers and would thus relieve other wall sections of the steam generated in them.

These figures indicate that while the steam velocities to be encountered in the water screens are substantially the same as in the lower tubes of the B. & W. type boiler, the entering water velocities may be nearly doubled. There are other points of dissimilarity in the operation of these two sections. The lower boiler tubes are nearly horizontal, and it may be assumed that the water portion of the mixture leaving the tube will tend to pass up along the bottom portion of the tube, which is the part exposed to radiant heat.

Action of Steam Mixture in Vertical Waterwalls

Does the steam-water mixture leave vertical tubes in a uniform mix or in slugs, or does the water corkscrew around the inner surface of the tube? When water is dropped on a hot plate, it does not appear to wet the plate and is apparently insulated from the plate by the steam formed. Some phenomena such as this together with the corkscrew flow of water, appear to take place in at least some of the vertical water-cooled walls, for tubes have blistered after being exposed for a time to high furnace temperatures. This would indicate that a lower steam-water ratio and lower velocities leaving the tubes would be desirable. Such can be secured only by more rapid water circulation. Increased water

velocities may require added water supply piping, more ample take-off steam pipes or forced water circulation. It will be apparent that higher steam-water ratios than those noted, due to higher furnace temperatures may involve earlier failure of the tubes and increased maintenance. It is claimed that water is dissociated if it comes in contact with overheated metal. The writer knows of no actual case where corrosion as a result of dissociation has been observed in water-cooled furnace walls.

An important factor in the design of water-cooled walls is the arrangement of water downcomers to provide an adequate supply of water to all tubes. Ample pipe area and a supply of water to both ends of the lower tube header appear desirable. The risers from the upper headers should lead directly to the boiler drum and must easily carry away all the steam formed or congestion would result, which would decrease velocities in the screen. The upper header must be of such size and slope that the steam from each tube can escape to the riser with equal ease. Otherwise certain tubes may have poor circulation, become steambound, and be liable to early failure.

Fall of Water Level with Burners Shut Off

The use of water-cooled walls has developed new problems with boiler drums and water levels. Suppose a large entirely water-cooled furnace of the fin-tube type is operated at high ratings with pulverized fuel and the burners are shut off owing to sudden stoppage of load. As there are no refractory walls to store heat, steam will cease to be generated in the tubes and the water in the boiler drum will be needed to fill the place of the steam in the boiler and wall tubes and in the circulating system. Unless the water volume of the drum or drums is large, the water level may fall below the bottom of the gage glass or, in an extreme case, may even empty the drum if a small single one is used. If the feed-water regulator continues to supply water to restore the level during the outage, then the drum will contain too much water should the load be picked up again quickly, and priming may result due to high water. This indicates that study must be given to water storage volumes in boiler drums and to feed-water regulation when designing water-cooled furnaces.

There is still another problem connected with boiler drums. The downcomer pipes for the waterwalls have often been placed near the ends of the drum. The rapid circulation of water to the water-cooled walls may seriously affect the water level in the gage glasses, which are also at the ends of the drums. It is quite probable that the water level may be much higher in the middle of the drum than at the ends, and this may result in wet steam leaving the boiler. This may require a relocation of either the water downcomers or the gage glasses.

Still another problem is the location of the discharge into the drums of the risers from the water walls. The geyser-like effect of this discharging mixture may require special baffling to prevent water entering the dry pipe.

One solution of these drum problems that has already been tried, is to provide a separate drum and feed-water supply for the water walls. However, it is probable that boiler designs can be modified to provide for these factors without using an extra drum.

It has been suggested that recirculating pipes be provided on the outside of the setting to connect the upper and lower headers of the vertical side walls. These might improve circulation in the tubes and would relieve the risers of much of the water that now passes up with the steam. Owing to the extremely rapid rates of evaporation in these tubes, the concentration of the recirculated water increases much more rapidly than in the boiler drum itself. Hence in time, as a result of such high concentration, a deposit of scale is likely to form unless the water screen is blown down frequently. This scale, as previously noted, is particularly undesirable. It is usually found inadvisable to blow down water screens when under load in order to lower concentration, on account of the possibilities of interrupting or stopping normal circulation during this operation and of forming steam pockets in some of the tubes. It has become general practice to blow down water-wall headers only when the boiler is not under load. The advisability of recirculating tubes requires further study.

Ash and Dust Also a Factor

The rate of radiant heat absorption is affected in a very marked degree by the presence of ash or dust on the heat-absorbing surfaces. Many attempts have been made to develop suitable devices to blow the dust off these tubes, but further improvements are desirable.

The preceding paragraphs have outlined some of the effects of radiant heat on water-cooled furnace walls. Many data must still be secured on the permissible velocities in water screens, side walls and piping and on the distribution of water to the tubes of the furnace walls. Further study must also be given to water levels in drums, feed regulation, blowing down of water-cooled walls, dust removal from tube surfaces and recirculation in the side walls.

Survey of Steam Required for Soot-Blowing

The results of a survey sponsored by the Prime Movers Committee of the N.E.L.A. of various boiler plants to determine the percentage of steam used for soot blowing are shown in the accompanying table. The plants included in this survey were divided into four classes: Plants using gas fuel; small stoker-fired boilers; large stoker fired boilers; and pulverized fuel fired boilers. The negligible quantity of steam used by the gas-fired boiler plants is not startling, as this fuel burns without cinder and but little soot.

The marked difference between stoker-fired installations is probably due to the fact that the smaller installations are older and are operated under poor load factors, resulting in the steam for soot blowing being a greater percentage of the steam generated. Older soot-blowing equipment on these units probably exercises considerable influence. The data indicate that the soot blowers on pulverized-coal installations are operated from two to three times as often as on stoker-fired installations. This is undoubtedly due to the large amount of soot and ash carried up through the boiler in the pulverized-coal furnace.

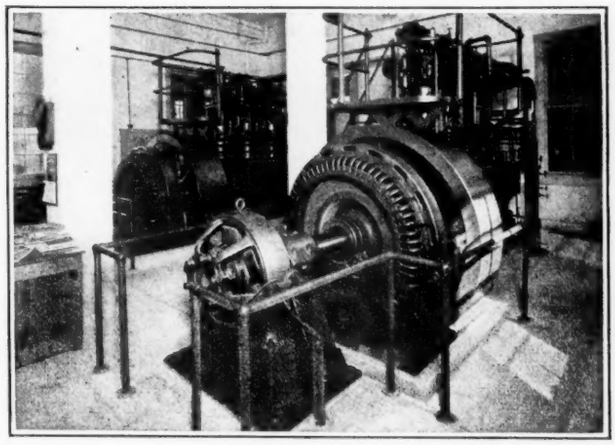
AMOUNT OF STEAM USED FOR SOOT-BLOWING

Type of Boiler Plant	Steam Used for Soot-Blowing in per Cent of Steam Generated
Natural gas fired boiler	0.0002
Stoker-fired boilers 12,000 to 23,000 sq.ft.	0.2
Stoker fired boilers 6,000 to 7,000 sq.ft.	0.6
Pulverized coal fired boilers	0.5

Predicting Oil-Engine Costs

By M. J. REED

USE of Charts Enables Prospective Costs To Be Calculated—Fuel Costs and Assumed Overhead Charges Most Important —Influence of Wages and Repairs on Total Costs



ALTHOUGH much discussion has been had on the subject of power costs of oil engines, attention has been devoted almost exclusively to actual data taken from existing plants. A prospective purchaser, if he wishes to forecast the cost of oil-engine power under his particular load conditions, must be guided by the results obtained in a plant similar to his own or by statements of engine salesmen. In the one case the analogy between the actual plant and the purposed one may be so approximate that the accuracy of the data goes for naught; in the other case there is always the fear that the salesmen's statements may be colored by enthusiasm.

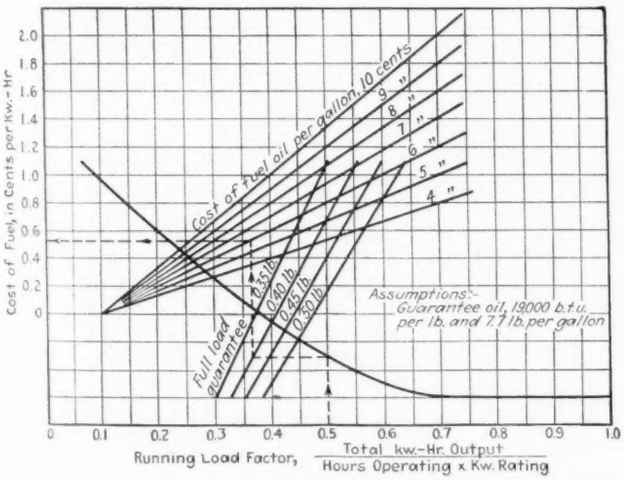


Fig. 1—Influence of fuel oil prices on operating costs

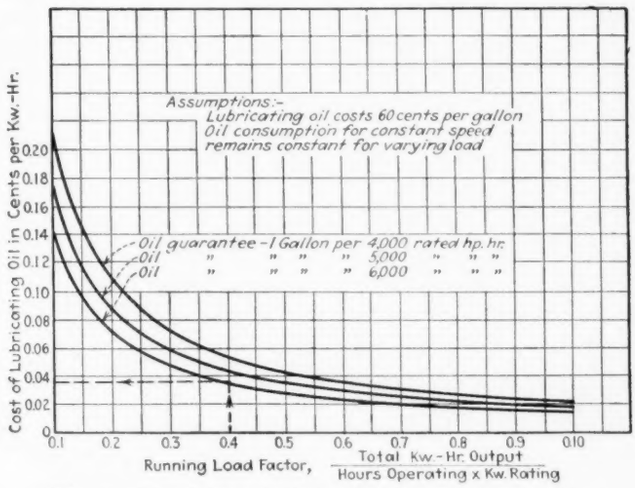

Cost of Lubricating Oil in Cents per Kw.-Hr.
Assumptions:-
Lubricating oil costs 60 cents per gallon
Oil consumption for constant speed remains constant for varying load
Oil guarantee - 1 Gallon per 4,000 rated hp. hr.
Oil " " " " 5,000 " " "
Oil " " " " 6,000 " " "
Running Load Factor, Total Kw.-Hr. Output / Hours Operating x Kw. Rating

Fig. 2—Variation in lubricating oil consumption

The quandary of the average purchaser is all the greater because of the nature of the product being considered. Were it a steam turbine, a centrifugal pump or an economizer, he would feel competent to size up the situation. However, lack of experience with the newer product makes most purchasers hesitate to attempt a calculation of the power costs and possible benefits that may be expected from this prime mover.

The total cost of power from an oil engine unit may be divided into five items: (1) Fuel oil cost; (2) lubricating oil cost; (3) attendance cost; (4) cost of fixed charges; (5) cost of repairs and supplies. Once the size and load conditions are fixed upon for a projected plant, all but the last of these items can be calculated with an accuracy more than sufficient for the purposes involved. While the cost of repairs and supplies cannot be so easily prophesied, the amount of probable error in a forecast of this item cannot materially affect the indicated result of the figures.

The cost of fuel oil per kilowatt-hour is affected by the price obtaining for the oil itself, by the efficiency of the engine in turning oil into horsepower, by the efficiency of the generator in turning horsepower into kilowatts, and by the load factor at which the unit operates. The chart, Fig. 1, is presented as a short-cut method of obtaining fuel oil cost from these factors. The curve in the lower part of the chart is patterned after the fuel consumption curve of a typical engine, in this case a solid-injection engine, but the chart applies equally well to other Diesels; account has been taken of the efficiency of the generator. Two series of lines make allowances for varying oil prices and full-load fuel consumption guarantees. The series of lines for different fuel oil guarantees is plotted by assuming a number of examples and plotting them up from the load-factor scale and back from the cost-per-kilowatt scale.

If a present user of an oil engine cared to do so, he could construct a chart of this kind that would give

accurate results for the particular oil-engine generator set. To do so, he should have a fuel consumption curve for the engine and a generator efficiency curve for the generator, both as obtained from actual tests. He could then plot such a chart by following the foregoing method.

The load factor to be used in connection with Fig. 1 should be the actual percentage of full-load rating at which the engine is operating while running, since, naturally, there is no consumption of fuel oil when

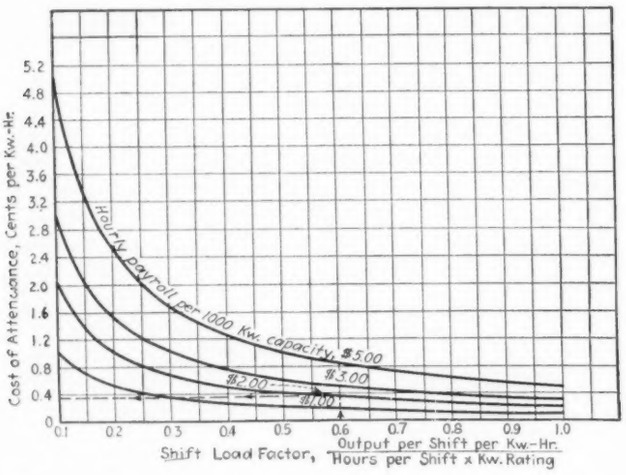


Fig. 3—Cost of attendance with varying load factors

a unit stands idle. Therefore, a load factor that is the result of dividing the kilowatt-hour output during a period of time by the number of hours in that period and by the kilowatt rating would be misleading if the unit had not been operating continuously throughout the period. For instance, assume a 200-kw. unit driven by an engine with a full-load fuel guarantee of 0.40 lb. of oil per b.hp.-hour, operating 240 hours per month, on six-cent oil, with a total output of 24,000 kw.-hr. The load factor to be used is 24,000 ÷ (240 × 200), or 0.5, and the cost of fuel oil per kilowatt-hour is 0.52c. If the full month of 720 hours were used in calculating the load factor, a cost much higher than this would be incorrectly indicated.

Lubricating Oil Consumption Guaranteed

Oil-engine manufacturers usually guarantee the lubricating oil consumption of an engine in terms of so many *rated* horsepower-hours per gallon of lubricating oil. Thus a 400-hp. engine which consumes one-tenth of a gallon of lubricating oil per hour operates at the rate of 4,000 *rated* horsepower-hours per gallon of lubricating oil. As the rating of an engine is a fixed figure, the assumption is that the lubricating oil consumption is a constant for a given speed through all ranges of load. The chart in Fig. 2 has been plotted upon the basis of this assumption. It is probable that the rate of oil consumption decreases as an engine approaches a no-load condition. However, the error in assuming a constant consumption is not great and is on the safe side. As in the case of Fig. 1, the load factor to be used in connection with Fig. 2 is the running load factor, since it is apparent that no lubricating oil is being used when a unit stands idle.

The cost of attendance varies greatly from plant to plant for the reason that the engineer in a small plant could usually take care of more capacity were it located in the same building. The curves in Fig. 3 indicate the cost per kilowatt-hour of attendance at different load factors for various hourly payrolls. For instance, a 500-kw. unit has one attendant paid $1 per hour. This corresponds to a rate of $2 per 1,000-kw. capacity per hour. The cost of attendance per kw.-hr. is 0.34c. at 0.6 load factor. The load factor that should be applied in the case of this chart is the result of dividing the kilowatt-hour output per shift or payroll period by the kilowatt rating of the unit and the number of hours per shift or payroll period. The running load factor could be applied only in case the unit operates continuously while the attendant or attendants is or are on duty.

How Fixed Charges Are Affected

Fixed charges are influenced by the first cost of the unit, the load factor and the percentages decided upon to cover interest, depreciation, taxes and insurance. It is not the purpose of this article to make any representations as to the proper percentages to assume. It is sufficient to state that opinions range from the pessimistic one that the life of an engine should be taken as not over ten years with the depreciation percentage 10 per cent, and that interest should be taken at the full yearly figure, to the optimistic one that engine life should be assumed to be at least twenty years and an allowance should be made for junk value, and that interest should be averaged over the depreciation period. Taxes and insurance are, of course, definitely determinable quantities for any neighborhood and are usually around a total of 2 per cent.

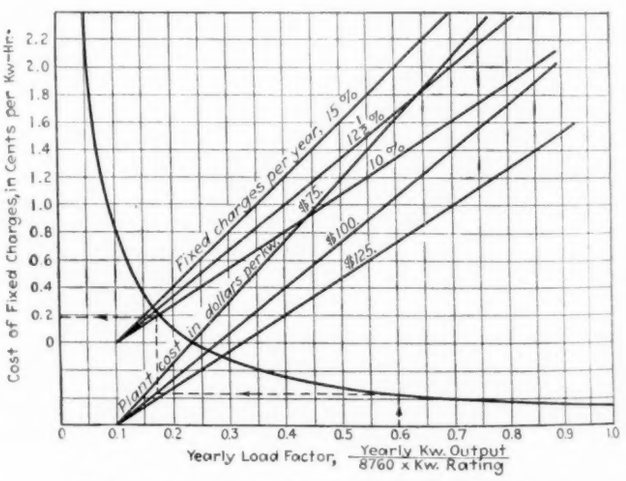


Fig. 4—The part played by fixed charges in determining costs

Once the cost of the plant is known and the percentages are assumed, Fig. 4 will serve to resolve the factors into the cost of fixed charges per kilowatt-hour. Here the load factor to be used is the result of dividing the total kilowatt-hour output for the period by the rating of the unit and the total hours in the period on the basis of 24 hours per day. This is the proper load factor because fixed charges mount up whether or not the unit operates at all. The cost of the unit per kilowatt should be based upon the cost of the whole installation, including freight, auxiliaries, foundations, piping, erection expense, etc. Solutions for a cost per

kilowatt not shown on the chart and for other fixed charge percentage rates can be found by proportioning an answer found by assuming a cost and percentage rate which are shown. For instance, assume a plant costing $95 per kw., a fixed charge of 11 per cent, and a load factor of 0.6. The cost per kilowatt-hour using $100 and 10 per cent is 0.19c. Multiplying this value by $\frac{95}{100}$ and $\frac{11}{10}$, the correct figure of 0.199c. is obtained.

An assumption that has been quite well borne out by numerous records is that the cost of repairs and supplies for the average oil-engine plant does not as a rule exceed $2 per horsepower per year. One horsepower, if in operation continuously for one year, will produce approximately 5,880 kw.-hr. through a generator. The average unit, however, will not operate continuously. Probably the average unit does not operate more than twelve hours a day or at more than 0.6 running load factor. This means a yearly load factor of 0.5 × 0.6, or 0.3, and on this basis a one-horsepower unit would produce 1,764 kw.-hr. per year. For preliminary calculations it would seem logical to assume that the cost of repairs and supplies will vary directly with the actual output. Thus it would follow that $2 divided by 1,764, or 0.113c., is a fair figure to assume as the cost per kilowatt-hour. If the assumption is too meager or too generous, the total cost of power is not greatly affected, since the probable error will be in the hundredths of one cent.

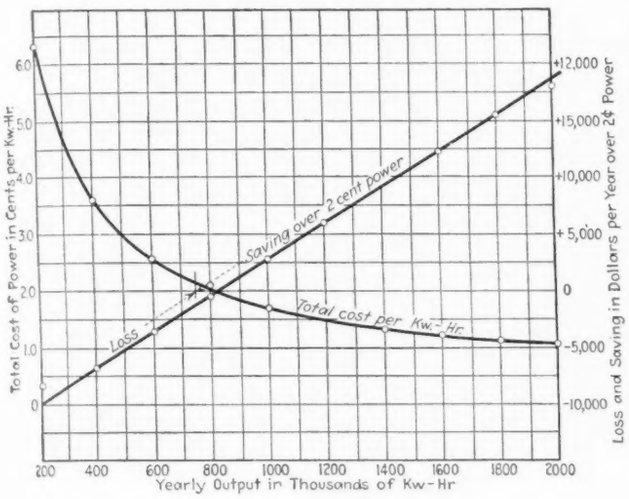


Fig. 5—When it is economy to buy power

Now that all the items entering into the cost of power have been considered, it is in order to inquire into the bearing of these items upon a choice between engines. Assume that a choice of an engine has been narrowed down to two makes: One has a fuel oil guarantee of 0.40 lb. of oil per b.hp.-hour at full load and the cost of the engine is such that the plant cost will be $100 per kilowatt; the other has an oil guarantee of 0.45 lb. and costs $5 per kilowatt capacity less. If the running load factor is 0.6, the cost per kilowatt-hour of fuel oil at 6c. per gal. will be 0.48c. for the one unit and 0.53c. for the other. If fixed charges are assumed to be 12½ per cent and the yearly load factor is 0.4, the cost per kilowatt-hour for the more economical unit will be 0.36c.; for the other unit, 0.342c. In this particular case the difference of 0.05c. in fuel cost overbalances the difference of 0.018c. in fixed charges resulting from $5 per kilowatt difference in first cost. A lower load factor or a lower price per gallon for oil, or both, will tend to throw the balance the other way. The safe method is to consider each problem by itself.

One further illustration: A prospective purchaser has estimated the total cost of oil-engine power for his load conditions to be 1.65c. He has assumed a running load factor of 0.5 and a price of 6c. per gal. for fuel oil. He can buy central-station power for a price of 2c. per kw.-hr. From the chart in Fig. 1, his fuel oil cost is seen to be 0.57c. for 0.40 full load fuel guarantee. His fuel oil cost must increase by 0.35c. to make his total cost of power go to 2c. Reading back from 0.92c. per kw.-hr., it will be seen that oil must go to 10.5c. per gal. before total cost reaches 2 cents.

The ultimate question in a consideration of oil-engine power costs is usually, How will the costs compare with the cost of purchased power? In order to demonstrate the answer to this question, the total cost per kilowatt-hour should be plotted against the yearly output. To illustrate a problem of this kind, assume a plant of 500-kw. capacity, to operate continuously for twelve hours a day, 365 days a year. Oil can be had at a price of 6c. per gal. The lubricating oil guarantee is one gallon per 4,000 rated hp.-hr.; the full-load fuel guarantee is 0.40 lb. per b.hp.-hour. One engineer at $10 per day is to be hired to take care of the plant. The plant is going to cost $50,000, or $100 per kilowatt, and fixed charges are assumed to be 12½ per cent.

The table shown has been compiled from the various charts, reading to the nearest hundredth cent. The output figures correspond to running and shift load factors of 0.1 to 1.0, and yearly load factors of 0.05 to 0.5, since it is apparent that continuous full-load operation for twelve hours a day would correspond to 0.5 yearly load factor. The figures for attendance were taken from the $2 curve and multiplied by $\frac{167}{200}$, since the hourly payroll is $1.67 per 1,000-kw. capacity. Repairs and supplies were fixed at 0.12c. per kw.-hr.

TOTAL COST OF POWER

Kw.-Hr. Output, per Year	Fuel Cost, Cents	Lubricating Oil Cost, Cents	Attendance Cents	Fixed Charges, Cents	Repairs, Cents	Totals, Cents
219,000	0.88	0.22	1.67	2.86	0.12	5.75
438,000	0.78	0.11	0.83	1.43	0.12	3.27
657,000	0.68	0.07	0.57	0.95	0.12	2.39
876,000	0.60	0.05	0.42	0.71	0.12	1.90
1,095,000	0.53	0.04	0.33	0.57	0.12	1.59
1,314,000	0.48	0.04	0.29	0.48	0.12	1.41
1,533,000	0.46	0.03	0.23	0.41	0.12	1.25
1,752,000	0.45	0.03	0.20	0.36	0.12	1.16
1,971,000	0.45	0.02	0.18	0.31	0.12	1.08
2,190,000	0.45	0.02	0.17	0.28	0.12	1.04

These total costs of power for the outputs given are plotted on the chart in Fig. 5. When the cost of power is known, it is an easy matter to calculate the saving or loss involved in using oil-engine power as compared to any given price for purchased power. In the chart the loss and saving as compared to power at 2c. is shown by the straight line.

The chart in Fig. 5 indicates the results that are probable for only one particular plant. The length of the working day, the operating days per year, the cost of oil, the performance guarantees, the pay of the engineer, the cost of the plant, the percentage for fixed charges are all subject to change. It is hoped these examples demonstrate the folly of accepting without analysis cost data compiled for an existing plant and basing decisions about a contemplated plant upon them.

The Benson System—Test Data Needed

THE experience of the Siemens-Schuckert company with their experimental installation of a Benson generator seems to demonstrate that the making of steam at the critical pressure is practical, and their own satisfaction with the system is indicated by the installation of a three-thousand-kilowatt unit in a subsidiary plant.

Of particular interest are the tube ruptures that seem to have occurred without causing serious trouble. It would appear that a tube failure at this super-high-pressure of thirty-two hundred pounds need not be contemplated with any greater fear of danger than ruptures at four hundred or six hundred pounds pressure.

It is to be regretted the tests made on the experimental boiler were not complete, for efficiency data would have been interesting, even though the installation was made under adverse conditions. The new installation, reported nearing completion, offers an opportunity for obtaining data representative of what this system of steam generation is capable of doing. It is hoped that such tests will be made and that the results will be available in the near future. As this installation is in an industrial plant, it should demonstrate whether it is capable of operating successfully without wide pressure variations when called upon to serve large fluctuating loads. If this ability is proved, its application to high-pressure power plants will demand further study.

Coal Driers

THE extended use of pulverized coal has emphasized problems in drying the coal. Drying is considered unnecessary with unit pulverizers on most coals, and with the central system on certain high-grade low-moisture coals. However, the average coal used on the central system of firing requires drying to secure low pulverizing cost and easy transport and feeding.

A clear idea of the principles of drying is necessary to understand the problems involved. As has been frequently pointed out, coal remains at the wet-bulb temperature of the drying gas as long as surface moisture is evaporating. It will not rise appreciably above this temperature until it has given up all surface moisture and even some of its inherent moisture. It is therefore possible to use highly heated air as primary air to unit pulverizers or to use quite hot gas as a drying medium in rotary or waste-heat driers. Spontaneous combustion will occur only in those parts where the coal has become thoroughly dry and generally only where the coal contains sulphur.

The preceding paragraph indicates that coal will be dried by evaporation in saturating the air or gas which acts as the heating medium. Experience indicates that this is one of the most effective means of drying crushed material. It is doubtful in the case of coal, if direct drying by passing the coal over a heated surface is really effective or economical. The moisture will be driven off only by heating the coal to a temperature high enough to enable it not only to evaporate the moisture, but also to heat the air with which the resulting vapor must be carried off. The wet-bulb temperatures of waste-gas driers usually run from one hundred and forty to one hundred and sixty degrees, while driers using hot air may have still lower wet-bulb temperatures.

These comments indicate that the action of coal driers should be studied carefully to note whether they conform to the recognized principles of efficient drying.

It has been suggested that a large portion of the surface moisture which is now removed in driers, might be separated by a machine using centrifugal force as in sugar centrifugals. This idea has merits and will probably be developed commercially in the near future.

The problem of drying all coals has not yet reached its ultimate development. Cheaper and better methods than those now used are still possible, and there is a real need for their early appearance.

Internal Stress

DESIGNERS of machinery have always based their designs on certain unit working stresses for each material. These working stresses are determined by dividing the ultimate strength by factors of safety which have been determined largely by experience. It was assumed that these factors would establish working stresses that would provide for any internal stresses that might exist in the material or that might be produced in the process of manufacture.

Recent research on the fatigue of metals has indicated that each material has a fatigue limit which is only a fraction, in some cases one-third, of the ultimate tensile strength. The fatigue limit is the highest stress to which the material may be subjected indefinitely without producing failure from repeated or alternating stress. The designer's factor of safety has in most cases been chosen from experience with failures that would probably now be credited to fatigue. The factors generally used provide working stresses equal to or less than the fatigue limit.

It will be evident when the fatigue limit and the working stress are close together, that the permissible internal stress must be small if early failure would be avoided. Internal stress is an indeterminate factor. Hence, where it may possibly exist, it will be well to choose large factors of safety in order to keep the working stress well below the fatigue limit of the material.

There is another side to internal stress that interests engineers. In the discussion of the so-called caustic embrittlement of metals that occurs in boilers, certain

engineers maintain that internal stress is an important contributing factor. They point out that driven rivets are under internal stress; that the riveted plates held by the rivets are under internal stress; and that the calking that tightens the joint will set up serious internal stresses in the boiler plate. These are all indeterminate stresses. Professor Parr has shown that the metal must be stressed beyond the yield point before embrittlement occurs. He also indicates that localized internal stress around the rivet holes in the plates may exceed the elastic limit.

This leads one to the consideration of how internal stress in boiler joints may be eliminated entirely. Welded joints might solve the difficulty if properly annealed, but these are not permitted by the Boiler Code. Hammer-welded joints suitably heat-treated, offer another possible solution. Or shall we finally have to make our boiler drums of one piece, as in the case of the high-pressure boilers in the Edgar Station in Boston and the Lakeside Station in Milwaukee?

Much of the engineer's troubles seem to be due to internal stress. More should be known of its nature, its effect on the structure of the metallic crystals and the possibilities of overcoming it with present methods of construction. This offers a large field for further research.

Protecting Electrical Equipment

PROTECTION of electrical equipment, although a feature of design, is closely associated with the kind of service is of primary importance, and in the pro- into operation and the amount of maintenance required to keep it running. In practically every plant continuity of service is of primary importance, and in the protection of the equipment this must be given first consideration. This in turn influences design. If an alternating-current generator is to be tied on the busbar with no protection against overloads, it must be designed with a suitable amount of internal reactance, the coils braced and other parts made to stand the effects of a heavy sustained short-circuit. Unless the machines are designed to stand such service, they should be protected in a way that will not subject them to conditions that may cause a complete failure of the windings or other parts.

Those who are responsible for the design of modern central stations, in general, appreciate the tremendous mechanical forces that may exist in switches, and between cables and busbars under conditions of sustained short-circuits. These forces are not as generally comprehended by designers of industrial power plants as they should be. Many industrial plants are taking on proportions that are comparable with medium-sized central stations and, on account of the short length of the feeders, can be subjected to short-circuit currents of great magnitude. In one system operating at sixty-six hundred volts, under its present setup it is possible to have short-circuit currents of sixty thousand amperes, and future expansion will increase this to eighty thousand.

In the design of such systems it is essential that the ultimate conditions be planned for. If this is not done, as the system grows there is a possibility that the rupturing capacity of switches and other factors of the system will be exceeded. When this point is reached, equipment that was entirely satisfactory in its operation previously, may prove inadequate and require replacing by more substantial apparatus. Another factor that must be kept in mind is the possibility of connecting with the local utility system. In some cases where this has been done, switching and other equipment that was adequate for the isolated system proved to be entirely inadequate after the interconnection.

Even after the system has been designed for the most severe stresses to which it may be subjected, there are certain conditions that must be protected against, such as sustained short-circuits on feeders, internal failures in generators, lightning if overhead lines are used, faulty operation, etc. Where protection is required, it should be ample for the existing conditions, since the difference in cost between such a system and one that is lacking in essential features affects the total cost of the installation only a small fraction of one per cent. If a generator burns out, the cost of the repair will exceed the cost of any system of protection it may be equipped with. Therefore, if means are available whereby the trouble can be prevented, the engineer should use them.

It is far more economical to invest in prevention than to spend for cure.

Problems of High Boiler Ratings

THERE is a decided tendency toward the design of large boiler furnaces so that high ratings may be secured from the superimposed and surrounding boiler surface. Aside from the problems introduced in the design and operation of the boilers and furnaces themselves, there are other problems in connection with certain of the auxiliaries.

Many plants are now installing air preheaters or high-pressure economizers or both to recover the heat in the flue gases. At high ratings the draft losses on these equipments become large and require forced- and induced-draft fans and motors of high capacity. At normal loads these large motors would operate at a small fractional load and therefore at low efficiency. One is confronted with the problem of whether two motors and fans should be installed for use at maximum ratings and what should be the relative capacity of the two fans.

Variable-speed fan motors or damper control over a wide range of boiler ratings introduce difficult control problems, so that some engineers have discussed a return to steam-turbine-driven fans for this purpose. The latter seldom fit well into a modern heat balance layout when bleeder turbines are employed. It is not an easy matter to determine the best form of control for such equipment when full consideration is given to first cost and reliability. Some systems recently installed have had excessively high first costs.

Another problem is feed-water regulation. High boiler ratings, particularly when large radiant energy absorbing side-wall surfaces are used with powdered coal, may cause wide fluctuations in water level in boiler drums when the load changes suddenly. The feed-water regulator must respond almost instantly to these changes, for the water capacity of the drum is small when the high rates of evaporation are considered. Furthermore, there is the problem of excessive water in the drums when load is suddenly greatly increased owing to displacement of water by steam bubbles in the tubes. Can a feed-water control device anticipate such rapid load increases? These new problems may result in radical changes in methods of feed-water control as well as draft control.

Ideas From Practical Men

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Preparing To Move a Control Storage Battery

A storage battery offers many complexities both chemical and electrical in ordinary operation, but there is a goodly increase during the period of moving a control battery from one location to another. One cannot go to a good battery, lift out the plates and pack them, unless it be for shipment to the junk man. Disassembly begins with a preliminary overcharge to a state of free gassing and is generally specific to a particular battery as to charge and time, but a two-hour free gassing is about right as an average. A second operation is discharging the battery, and if a lighting or some other load is available, so much the better. The discharge should continue until the cells reach 1.7 volts per cell, at which time discharging is discontinued and the electrolyte drawn off.

The electrolyte can be siphoned with a small rubber hose into carboys or to glass or earthenware pitchers and poured into the carboys as the case may be. The carboys should be clean, and no metal utensils should be used to handle the electrolyte. When filled, the carboys should have their caps wired on and sealed with paraffin, sealing wax or other compound. Do not use cork.

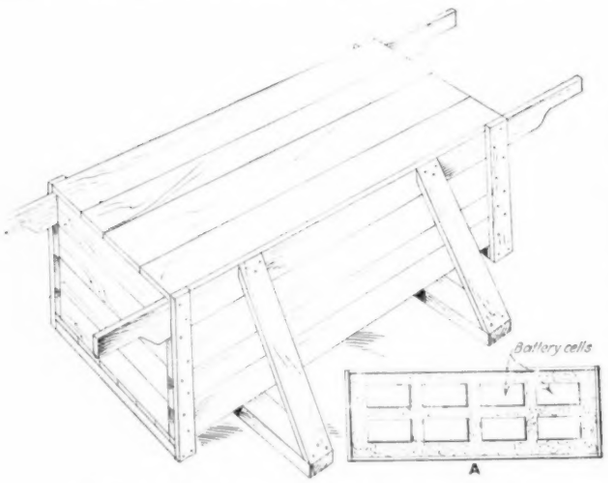


Fig. 1—Type of case used for packing storage-battery cells

When a cell has its electrolyte removed, it should immediately be filled with distilled water. Another method is to leave the cell unfilled but to keep the negative plates cool by spraying water on them. When all electrolyte has been removed and replaced with distilled water, discharge can be continued and is usually completed to short-circuit, but I prefer to about 0.5 volt per cell. The final discharge should be in accordance with manufacturer's rating and can be accomplished in many ways, preferably through a variable resistance.

This brings the cell down to a condition for disassembling, and as electrolyte is likely to be spilled, it is advisable to have a strong solution of baking soda handy for sprinkling on the floor. Glass tops used on the cells can easily be washed and crated. Electrical connections can be disassembled and greased with vaseline and the cells removed and placed under a faucet for flushing. Do not use a direct stream on the plates; it is better

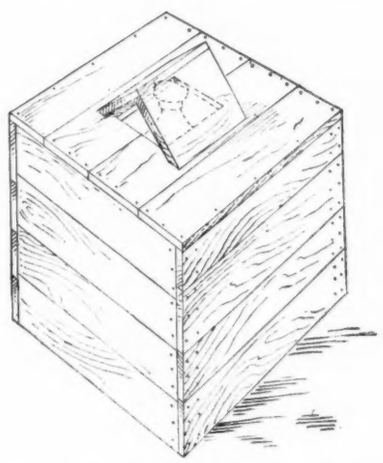


Fig. 2—Electrolyte carboy ready for shipping

to tie a cloth over mouth of the faucet. The use of raw water for flushing is more or less of a question as to its quality, but ordinary water will have little or no bad effect at this stage of disassembly. Spacers should be removed prior to flushing. It is good practice to throw them away, but if they must be saved, they should be thoroughly washed, after which they can be kept in water until shipment. They should then be packed in sawdust saturated with water in a box lined with felt roofing paper.

Spacers between the plates will be necessary, and I have used blotting paper, such as is generally used in oil filters, whose size approximates that of the plates.

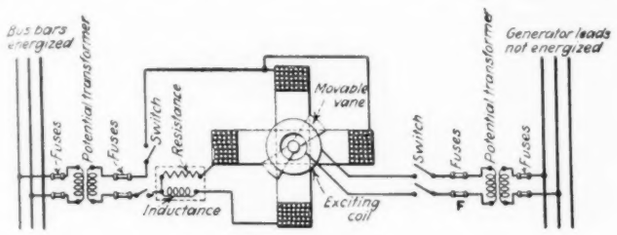
The actual packing of the battery entails no extraordinary procedure. The trays and tops are packed in one carton, with the usual care given glassware. Carboys are self-contained units, as in Fig. 2. The cells can be packed in convenient boxes, Fig. 1. A convenient number of cells to put in a box is two rows of 4 or 5 as at *A*, Fig. 1, with ample packing on bottom, sides and allowance for top packing. Excelsior is not so good for top packing but has its usual value for the sides and bottom, and paper can be used for the top, but the plates should be packed securely; this about completes the task except for cartage.

E. J. Morrissey, Chief Elec.
Aurora, Ill. Western United Gas & Electric Co.

Unusual Action of a Synchroscope

At one time an operator complained that when he closed the synchronizing switch on a large switchboard when the generator was not running, the synchroscope pointer would rotate slowly. It was his belief that the instrument or wiring was out of order. Everybody who looked at it was of the same opinion, but when it was checked over everything was found correct.

In an examination of the circuit it was noticed that when the secondary fuses of the generator potential



Connection diagram for synchroscope

transformer were removed, but those of the busbar transformer left in circuit, there would be no movement of the synchroscope pointer.

As the instrument had operated satisfactorily when synchronizing, we came to the conclusion that the rotating field, energized from the main busbars, induced a current in the exciting coil of the movable vane. The circuit for this coil is completed through the generator's potential transformer secondary. This current magnetized the vane and caused it to be rotated by the rotating field of the coils connected to the busbars, giving the same condition as when the generator was out of synchronism with the bus, or as an induction motor operates.

E. H. STIVENDER.

Los Angeles, Calif.

How To Make Steam Hose Last Longer

The mill superintendent was complaining to the salesman about the trouble he was having with steam hose.

"Looks like I can't get any good hose any more," he grumbled. "Take this piece here for instance," pointing to a piece on the floor. "I got just one week's service out of that hose before it blew out."

"Maybe the tube was ruptured," suggested the salesman, who had heard similar complaints.

"Don't know about that," said the superintendent. "If it was ruptured, I can't account for it. The way I've got it figured out is that it was just a bum piece of hose."

"Well, we can find out mighty quick." Suiting his action to his words, the salesman picked up the end of the hose and pulled out his pocket knife.

"It didn't blow out on the end," remarked the superintendent as he watched the salesman cut the hose longitudinally over the part that covered the coupling.

"I know that," replied the salesman, "but at the same time this is where your trouble is coming from and here is what is responsible for it. If you will look at the end of this pipe coupling, you will find the threads burred."

The superintendent inspected the nipple critically. "Can't see why a burr in the end would make the hose blow out," he exclaimed somewhat doubtfully. "What's that got to do with it?"

"It's this way," explained the salesman. "If sharp projections or burrs happen to be on the end of the pipe coupling the tube becomes ruptured at this point and the rupture permits air, water or steam to penetrate the fabric. No hose, regardless of what kind it is, will withstand any amount of pressure if the tube has been injured."

"But it didn't blow out on the coupling end," argued the superintendent.

"Hose blowouts do not usually occur right at the point where the coupling is applied," continued the salesman, "but may follow the plies down the length of the hose sometimes as far as ten to twenty feet from the coupling end."

"How can I prevent this in the future?" asked the superintendent.

"By removing the burr with a file if you use a piece of iron pipe for a coupling, and by turning off the threads if you use a nipple."

Jackson, Miss. G. M. RITTELMEYER.

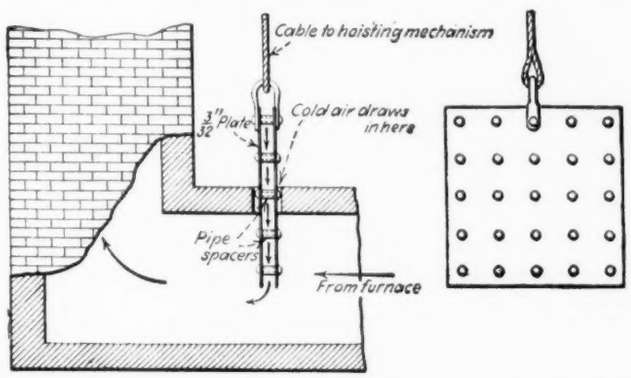
Sheet-Metal Air-Cooled Damper Eliminates Troubles from Warping

A cast-iron damper in the duct leading from a furnace to a stack became so warped and cracked that it had to be renewed.

There was no new casting available, so a damper had to be made from such material as could be found around the plant.

After due consideration it was decided to make it from sheet metal about $\frac{3}{32}$ in. thick, a supply of which was in stock.

Some of the boys hooted at the idea of the thin material withstanding the heat when the heavy cast iron would not, but something had to be done, so two pieces



Damper built of two sheet metal plates riveted together with pipe spacers

of the right dimensions were cut out, but instead of riveting them together flat, a number of pieces of pipe were cut, about $\frac{3}{4}$ in. long, and used as distance pieces between the two halves, the rivets passing through both sheets and the distance pieces.

This made, in effect, an air-cooled damper, as the draft of the stack pulled cold air between the two plates and through the opening in the brickwork around the damper as indicated by the arrows in the sketch.

This damper has been in use for some time and is still in good condition, and the same idea could undoubtedly be applied in other troublesome places.

Kansas City, Kan. P. EMERSON.

Comments from Readers

Can a Feed-Water Regulator Save Coal?

Referring to P. H. Hogan's article in the May 10 issue, "Can a Feed-Water Regulator Save Coal," he has, without doubt, proved his case, so no argument is necessary, but being absent from the plant forty-five minutes at a time seems a trifle unsafe. If this engineer had had a feed-water control, he might have stayed away forty-five minutes longer, but the control would not guarantee the water level if the supply stopped. But my story is of a different type.

A certain plant had a closed heater several sizes too small and a dyehouse several sizes too large. A young salesman wanted to guarantee the everlasting 5 per cent saving in coal that a feed-water control system is supposed to give. I asked him if he did not wish to diagnose the case first and talk saving afterward, but he said the company had yet to meet its first Waterloo.

Our method of operation, gained from three years' experience, was to set the feed valves to give a temperature of 170 deg. F. Too fast a feed would reduce this temperature to 120 deg., and too slow a feed would give 210 deg.

Of course we would like 210 deg. at all times, but this was practically impossible, so 170 deg. was found to be the most economical point.

The water level in the boiler would vary from one to two and a half gages, but the efficiency was the highest at the point named. After our young friend had followed the plant through a couple of cycles, he admitted his mistake and then wanted to sell me a bigger heater, but our low-pressure steam supply would admit of only 170 deg. at all times.

A place for everything and everything in its place is applicable to feed-water controls as well as blacksmiths' tools.

C. W. PETERS.

New York City.

An Engineer's Art of Getting Things Done

In the April 26 issue James F. Hobart gives an interesting and, no doubt, true story for engineers to ponder over. We have the "Jim Shipley" type in real life all over the world, doing their best to prove that the plant engineer's greatest factor for success is with himself and not obtainable from others. Reading Mr. Hobart's story recalled a "Jim Shipley" known to the writer. He also is a plant engineer who gets things done, but in doing so appears to enjoy a life of ease. He is looked up to by everyone from the proprietor down; everything about his plant is neat and tidy, and his assistants strive to please him, making the plant a model of efficiency. He is consulted about the smallest detail and no one attempts to interfere with "Jim" or his work, least of all the proprietor, who, like Mr. Hobart's "Peter Smith," has proved his engineer to be the right man in the right place.

I also knew this "Jim Shipley's" predecessor. He always appeared to have the whole world against him. He was hunted up and down by everyone; even the boys took a hand in telling him what he had to do, and he meekly carried out instructions. Being continually on the run, most of his work was rushed through by temporary methods, resulting in everlasting muddle for himself and his plant. No one thought of consulting him about new equipment, and any that came along, first surprised him and then added more trouble. His assistants did much as they liked, a great deal of which consisted of watching him slaving away at his breakdowns.

For this state of affairs and his misery he always blamed his employers and all connected with them, but time and the "Jim Shipley" previously referred to have proved that the engineer's position depends very much upon himself.

The art of getting things done, as displayed by these "Jim Shipleys," is nothing more nor less than full confidence in themselves to make a success of their jobs, and by concentrating upon this, allowing nothing to turn them into side issues, soon put a polish upon their plants that cannot be overlooked by the proprietors or anyone else. Eventually this polish draws the confidence of the employers which, as a matter of course, carries with it the confidence of all others in the business.

F. P. TERRY.

Belfast, Ireland.

What Made the Motor Howl?

The article in the May 10 issue of *Power* entitled, "Repaired the Fault Without Finding the Trouble," is remindful of a similar experience in my own plant occurring a few weeks ago. In my case though, removing the ground in a rotor really did cure the trouble. This ground trouble was in a rotor on a 20-hp. two-speed motor operating at 900 to 300 r.p.m., with a two-winding stator on a geared traction passenger elevator. The squirrel-cage rotor winding of this induction motor was insulated, all bars having cell insulation in the slots and the bars held with wooden wedges. The bars were connected at each end with four end rings spot-welded to each bar.

Trouble started with the bars working loose in the slots and the entire cage sliding on end, but none of the end rings was loose. The motor started to make a whining noise, and in order to eliminate this it was decided to take the rotor out, recenter the bars in the slots and tighten them with new wedges obtained from the manufacturer. This was done and a lamp test showed a dead ground in the winding, but the rotor was replaced and tried out. The motor operated satisfactorily except at the time of changing from high to slow speed, when it howled like three or four tomcats giving a moonlight serenade on a backyard fence. This occurred only at the time of changing from the high-speed stator winding to the slow speeds.

I came to the conclusion that rewedging the rotor bars had forced them to the bottom of the slots and that the cell insulation was damaged and the ground

created the howling. Otherwise, there was no trouble, as the motor had sufficient starting torque. As this motor is in a hotel building and the noise carried down into the building, it was annoying to the guests and had to be remedied.

I took up the matter with the elevator manufacturers, and they declared the ground in the rotor would have no such effect. Experts from a local armature repair shop were called in and they made the same statement, saying all rotors are grounded nowadays and it made no difference, intimating the trouble was in the stator between the high- and slow-speed windings. I still contended the trouble was in the rotor insulation, and they agreed to reinsulate it and did so, rewelding the end rings, which they took off one end to remove the bars, and no bars were loose when they removed the rings.

After the repairs were completed, the motor was put back into service and ran noiselessly and has continued to do so. It was a surprise to the armature repair men, as they declared the noise would be there just the same with the reinsulated rotor. Here is, apparently, a true case of reinsulating grounded rotor bars clearing the trouble. If it made no difference, why were the bars insulated originally, and why did this ground cause a disagreeable noise and howl on changing speed from one stator winding to the other? When the slots were reinsulated, why did the trouble cease? Would it be caused by a sudden momentary rush of current in the rotor due to a change of current flow from one stator winding to other winding? Anyhow, clearing the ground cleared the trouble. C. DICKERSON.

Topeka, Kan.

A Boiler That Almost Exploded

Some time ago the fire under a gas-fired horizontal return-tubular boiler was left burning without attendance from 10 o'clock in the evening until 4 o'clock the next morning. When an employee came on duty at 4 o'clock, he found the boiler room in an uproar from the popping off of the safety valve. The whole boiler room was filled with steam, and the boiler was red hot

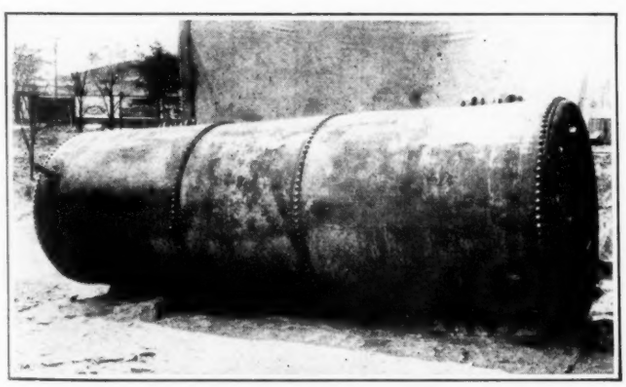


Fig. 1—Damaged boiler removed from setting

from the intense heat of the fire. He promptly shut off the gas. Next morning, when the boiler had cooled down, it was observed that the shell courses between the girth seams had swelled up like balloons, that the rivets were sheared part way through and that all the tubes were loose in the boiler heads. The metal had been yielding until rupture was just about to occur!

Some time later I examined this boiler, and in all my experience I have never seen a case where a violent explosion was so imminent. Just a few seconds more and the entire plant would have been razed to the ground. The boiler was owned and operated by the Seward Wire Co., of Parkersburg, W. Va. It was insured, but the damage to the boiler was not covered because no sudden and violent explosion had occurred. But the loss was so close to the border line between

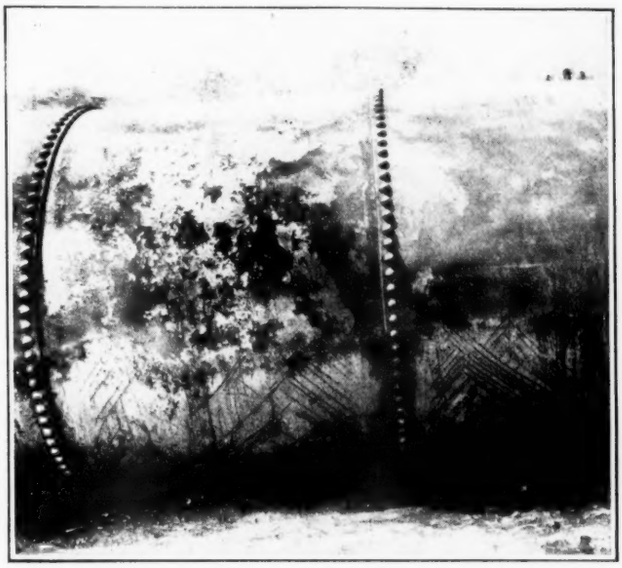


Fig. 2—Section of boiler showing strain or Lüder lines in damaged portion of boiler sheets

an accident covered by the policy and one not covered, that a check for $1,000 was sent to the assured.

Upon a close examination of the boiler after it was removed from the setting, distinct strain or "Lüder" lines were found on the middle and front sheets, extending from each edge of the unburned portion along the bottom of the boiler as shown in Figs. 1 and 2.

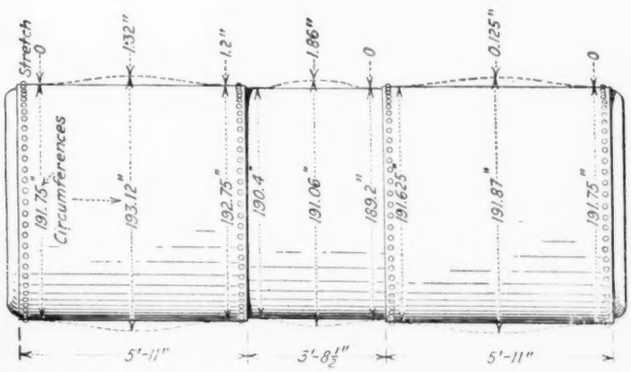


Fig. 3—Diagram with dimensions, showing the circumferential stretch that took place in the sheets due to overheating

The extent to which the shell courses increased in circumference between the girth seams is indicated in the drawing, Fig. 3.

WM. H. BOEHM, Vice-President,
New York City. The Fidelity and Casualty Co.

[If a steel test specimen be pulled in a testing machine until stretched beyond the elastic limit without actually rupturing, there will appear on the surface definite diagonal lines indicating the parts of the metal

that had been subjected to the greatest stress. These lines were first discovered by an engineer named Lüder, hence they are termed Lüder lines. These lines, also known as Hartman or Cooper lines, occur where the deformation of the underlying metal is sufficiently great to overcome the adhesion and cohesion of the mill scale. They follow shear lines and also lie at right angles to the maximum tensile or compressive stresses. The appearance of these lines in this case is a definite illustration of overstressed boiler sheets.—Editor.]

Dollar Efficiency Versus Technical Excellence

The communication of C. W. Reynolds in the May 17 issue deals with matters of great interest to the engineering profession, especially with respect to the question of the adjustment of the engineer to the economic requirements of the community.

It is undoubtedly true that the college-trained man often fails to understand properly the financial factors of his problem, but I think that we are inclined to place too much of the responsibility for this upon the colleges. In view of the tremendously extended field of present-day engineering practice, the problem of giving the student even an elementary knowledge of the fundamental principles of engineering science in four or five years, becomes a very difficult one, which must of necessity be solved by a process of elimination and selection; and the question of how much time, if any, may be advantageously devoted to other than purely technical matters is one concerning which there may be a wide difference of opinion.

I am inclined to believe that technical education will shortly have to undergo a revolutionary change. At present we are trying to do something that is becoming every day more impossible. Our colleges are attempting to turn out engineers, apparently quite oblivious to the fact that engineering may mean anything from selling dish washers under the impressive title of "sales engineer" to the carrying out of the most highly technical scientific investigations.

There is no doubt that there are certain subjects that should be taught to all those who expect to call themselves engineers. On the other hand, the impossibility of evolving any kind of blanket education by means of which an even partly finished product can be turned out, equipped for any of the rapidly increasing number of activities classed under the head of engineering, is becoming more and more obvious.

It may be found advisable to provide courses in commercial engineering in which students will be taught to analyze their problems in terms of dollars and cents rather than in terms of a more technical nature and to give degrees in this branch of engineering. On the other hand, it is undoubtedly true that most of those who have been successful in business and financial life have received their commercial training in the school of practical business, and it is men with this kind of training with whom the engineer will most often deal.

If it is possible, as it undoubtedly is, for many men to gain a knowledge of finance and economics in this manner, the question presents itself as to why the engineer so often fails to do so.

Unfortunately, opportunities for engineers to engage in business on their own account are limited, and the average young engineer expects to work as an employee all his life. He generally finds himself in the employ of a commercial or manufacturing organization and is given to understand that he is supposed to confine his attention to purely technical matters and that the financial and business problems of the organization are none of his concern.

Even the office boy is encouraged to believe that some day he may hold an important executive position and take his part in the solution of the financial problems of the company, but not so the engineer; and yet when there is a question of the cost of engineering operations, the engineer is supposed to know all about it, especially if the cost runs over the appropriations, and in all probability he had been told in the first place that if the work could not be done for the price someone else thought it could be, he was no good as an engineer.

As a matter of fact it takes some moral courage for even an independent consulting engineer to tell a client that the operation is going to cost one hundred thousand dollars when the latter expects to spend about twenty-five thousand, and for the average employee who has not been invited to take part in the general financial councils of his company to tell the financial powers that they do not understand the problem, often calls for a degree of courage that borders upon recklessness.

It appears to me that a great deal of the trouble is due to the standing of the engineer in relation to the business organization. This standing is too often not what it should be, and we may reasonably ask whose fault it is. Perhaps partly ours and perhaps partly that of our system of education; in any event the solution of the problem calls for closer co-operation between the technical and financial elements of the business fabric. There is no doubt that the idea of engineering service has hitherto never been properly sold to industry. There is too little understanding on both sides as to the nature and scope of service which the engineer may rightfully render to business and the community, and until the subject is better understood we cannot correctly solve the problems relating to his education and training.

The matter is of vital importance to all engineers. We are not at present taking the place in business and in the community to which we should aspire. Conditions generally prevalent do not afford to the rank and file of engineers sufficient opportunities for broad personal development and experience, so that they may become equipped to take their proper place in the management and control of industry, which is so greatly dependent upon them for its existence.

The problem can be solved only by mutual co-operation. If business and financial executives are not seeking in the ranks of technically trained men for material from which to develop their successors, it is most important that we should know the reason. Probably it is due to lack of understanding on both sides. Perhaps there is something wrong in the preliminary training of our men. Undoubtedly, as before indicated, there is often something lacking in their post-graduate experience. On the other hand, those who are familiar with our young technical graduates and realize the amount of hard work they have put into their training and that they are the pick of a goodly company, perhaps 75 per cent of whom have failed to survive the perils and trials of a technical course, must believe that among them should be found material of the highest quality for our future industrial leaders, provided adequate facilities are provided for their development.

Newark, N. J. J. O. G. GIBBONS.

Mechanical Engineers Meet at White Sulphur Springs

Successful Combination of Technical and Social Activities at West Virginia Resort—Several Power Papers of Outstanding Merit—Attendance Over 250

EVEN before the close of the first day of the Spring Meeting of the American Society of Mechanical Engineers, which opened May 23 at White Sulphur Springs, W. Va., there were all the evidences of a most successful meeting. Not only were the papers of exceptional merit, but the social diversions were of a high order, especial care being taken to entertain the ladies.

The outstanding feature of the meeting was the dinner Tuesday evening at which the Society's medal was conferred on Wilfred Lewis in recognition of his work on gear tooth design. The presentation was made by President Charles M. Schwab.

Pendred Speaks

Loughnan St. L. Pendred, Editor of *The Engineer*, London, England, spoke of the impression made upon him by his five weeks' visit to this country. He felt that the American Society of Mechanical Engineers and the Institution of Mechanical Engineers could do much toward tying together the English-speaking engineers. He was much impressed with the broad way in which American engineers did things. This country had the wealth and resources of the world, and how it was to meet its world obligations was on the knees of the gods.

Mr. Pendred stated that it would have taken considerable insensibility on his part not to have been impressed with the immensity of American manufacturing and power plants, coming as he had from little England. Yet in some respects the latter showed a superiority. In America Babe Ruth received, so he understood, $75,000 per strike, while last year England paid a thousand times that price for a single strike. In some other respects England had displayed a supremacy. The difficulty in America of finding parking space had been overcome in his home country by the production of the Baby Austin car, which could go anywhere. At present its wheel base was three inches shorter than formerly, due to the requirement that it must be short enough to be washed in the kitchen sink.

He extended the greetings of the Institution of Mechanical Engineers, of which he is Vice-president, and thanked all for the many kindnesses he had received.

Central Station Power Session

The first meeting of interest to *Power's* readers, on central station power, was held Monday afternoon.

"High-Pressure Steam at Edgar Station," a paper by I. E. Moultrop and E. W. Norris, was read by the latter.

In a second paper, entitled "High Steam Pressures and Temperatures at Crawford Avenue Station," A. D. Bailey discussed the operation of that station of the Commonwealth Edison at Chicago.

These two papers will be abstracted in an early issue of *Power*.

Power Session Discussion

In a written discussion John Anderson, Milwaukee, Wis., stated that failure on the part of the Edgar station designers to follow an outstanding trend in boiler and furnace design, namely, the use of greater radiant-heat absorbent surface in the furnace, was the basic cause of the slagging troubles mentioned in the paper. These troubles were not due to high pressures and should have been ignored in the paper. Radiant-heat absorbing surfaces have been provided on all six exposures of the Lakeside plant, yet record combustion efficiencies have been obtained. About 60 per cent of the heat released is picked up by these surfaces; the radiant-heat superheaters and reheater have averaged 45,000 B.t.u. per sq.ft. per hour.

With high pressures the choice of boiler largely determines the amount of operating trouble. Handholes should be avoided as far as possible. He felt that high pressure was a boon, as it resulted in a decrease in steam-bubble size, with a consequent increase in heat-carrying capacity of the tubes and drums. At Lakeside it was found that the water levels in the two upper drums of the Stirling boiler were coincident and closing of all twelve feed valves caused no fluctuation in the water level as indicated in the water glass drum. Popping of safety valves did not affect the water level, and automatic tripping of the high-pressure turbine load and bypassing of the high-pressure steam to the 300-lb. line could not be detected on the gage glass.

After 2,500 hours of operation the 7,500-kw. Lakeside 1,250-lb. turbine showed no sign of pitting or of blade distortion. Seal leakage from 1,250 to 300 lb. pressure was only 0.9 per cent of the steam handled..

Mr. Anderson stated that although some plants were considering low pressures, at Milwaukee the next installation, to occur next summer, will be a 1,400-lb. boiler and a 12,000-kw. turbine similar to the present high-pressure apparatus.

As to the troubles at Crawford Avenue, it was his opinion that steel castings are subject to leakage at high pressures. However, much could be eliminated if plant designers did not insist on so many special and fancy shapes. He doubted the efficiency of X-ray examination. At Lakeside the piping in the 1,400-lb. section had been satisfactory.

Mr. Anderson felt that Mr. Bailey was to be commended for admitting that stokers had not the ability to meet all the fuel-burning requirements. It was stated in the paper that refractory water-cooled walls were necessary with stokers, but from his viewpoint these were undesirable for high-pressure boilers, for if expensive boiler tubes were to be put into the furnace, they should be worked at a high rating.

In conclusion he felt that the slightly higher cost of the 1,400-lb. equipment over that of 300-lb. apparatus would be repaid from savings within one year.

F. H. Morehead, Walworth Manufacturing Co., Boston, did not agree that steel castings were uniformily bad. In one large plant no casting had shown a leak after a year's operation.

V. M. Frost, New York, said that in his opinion steel castings were open to suspicion and that he eliminated all such castings so far as possible.

Higher Temperatures

Professor Christie, Johns Hopkins University, expressed the belief that temperatures above 750 deg. could be used in power plants inasmuch as 850 deg. and 900 lb. were used in oil refineries.

L. St. L. Pendred, England, commented humorously on the fact that after weeks of searching for the truth in this country he had not been able to find anyone who was willing to state what was the most economical pressure.

Another bewildering phase of American engineering was the universal habit of each interviewed engineer to announce that in his particular plant absolutely no trouble had been experienced, but that in John Doe's or William Smith's plant there had been no end of trouble, and gave the tip that the latter two would probably declare they had no trouble—but he, Mr. Pendred, was not to rely too heavily on their statements. He was, so to speak, left up in the air, or at least high and very dry.

W. N. Polakov then related a study made of the power requirements in a Southern paper mill where it was found that the superposing of a high-pressure

turbine and boiler upon the existing 175-lb. installation would permit the elimination of the purchase of 40,000,000 kw.-hr. yearly as well as a fuel saving of $160,000.

High pressure was the solution of the cheap power problem, so Francis Hodgkinson, Westinghouse Electric & Manufacturing Co. felt, and fixed charges would determine how high it would be economical to go. There was no reason why high pressures should disturb the turbine design, but he could not be so confident about high temperatures. New materials were not needed, but there was some uncertainty as to how present materials would stand up in high-temperature service. Research has revealed that it is safe to use high temperatures with the shapes tested, but the general structure design has a tremendous influence. Large machines cannot undergo the distortion permissible in small parts, and for this reason he felt that even 925 deg. F. would be safe, but for small turbines only.

George Orrok expressed the opinion that economics and not thermodynamics would always dictate the working conditions. Undoubtedly, there were still some "bugs" to be eliminated in high-pressure work. In regard to the Benson boiler he had seen one in Germany after it had undergone 4,000 hours of service at 850 deg. F. The alloy-steel superheater tubes showed no signs of erosion. He was impressed with the action of the turbine, the casing of which was red hot, but its operation was satisfactory.

In his summary Mr. Norris stated that at the Edgar station all steel castings were X-rayed. No operating trouble due to the high pressure had appeared, but some handhole gaskets had leaked. On the turbine carbon rings were used in place of labyrinth packing. The original laminated stator of the generator had displayed "whipping" symptoms and it had been replaced by a solid rotor.

In discussing the paper by A. D. Bailey, H. W. Leitch, United Electric Light & Power Co., New York City, stated that in the Sherman Creek station when two water-cooled side walls were installed and radiant superheaters on the rear walls were put on boilers using pulverized coal, fine ash deposits on the walls. This produced a slight insulating effect, and the film grew until an equilibrium was established between heat absorption and reflection. The coat next the metal surface was soft, while at the outside a reddish black glazed slag appeared. In some cases the molten slag ran over this surface. Evidently, a large amount of reflecting power was retained by this coating. It was apparent, then, that erroneous deductions might be drawn as to the actual temperatures, since a temperature of 2,400 deg. F., the fusion point, existed but a few inches from the metal surface, which was at about 1,600 deg. F.

At the East River station, where the flame takes the form of a U, the deposits were quite different, being of a powdery ash. It was seldom over ½ in. thick and was brushed off with ease. Attention was called to a set of curves developed by the late Mr. Broido, which showed that it was possible to operate a refractory furnace at as high a rating as was possible with water-cooled walls, the furnace temperature being the same.

Fuel Session

At the Tuesday morning session held under the auspices of the Fuels Division, George Orrok presented a paper on "The Economics of Coal Carbonization in the United States."

He outlined the history and development of the coking of coal and discussed the economic aspects of applying the process industrially and in connection with power generating plants. His paper will be abstracted more fully in a later issue of *Power*.

In the discussion, H. D. Savage, Combustion Engineering Corporation, expressed the opinion that observations made five to ten years ago should not be used in determining the economies of coal carbonization at present. He pointed out that engineers as a whole had decried powdered coal when first introduced, but that in spite of this he had put this system into commercial use. Further argument was developed from a study of a contemplated low-temperature carbonization plant at the Jordan power plant near Salt Lake City, Utah, where it was found that a profit of $1.47 could be made per ton of coal processed. The greatest field for such fuels was in the domestic heating field, where a smokeless fuel was needed.

L. St.L. Pendred pointed out that Thomas Parker of England was the first to build a low-temperature plant, but he could not sell the gas to the gas companies and the public would not buy the coke. He failed, as did many who initiate new processes. Although the English Government was supplying funds to several such undertakings, he did not believe processing would ever succeed in England.

Professor Trinks expressed the belief that in the Midwest, where smoking coal was used for household heating, processing would come into existence.

F. A. Scheffler, Fuller-Lehigh Co., mentioned that 17 per cent. of the central station power was being developed in pulverized-coal plants and believed that in the remaining 83 per cent. was a field for low-temperature carbonization.

W. H. Polakov stated that he had used briquets in an emergency and improved the boiler efficiency, burning the briquets on a Murphy Stoker.

Oil Power Session

Three papers were presented and discussed at the Oil Power Session held Wednesday morning.

Edward G. Bearsley, in his paper entitled "The Study of Oil Sprays for Fuel Injection Engines," described the research work being done at Langley Field, Va., by the National Advisory Committee for Aeronautics on injection-spray formation.

The study of the compression-ignition, solid-injection type of engine, with regard to its possible development for aircraft use, was started at the Langley Memorial Aeronautical Laboratory at Langley Field, Va., in 1921. The general problem was analyzed and an attempt made to attack it from all angles. One of the things about which actual knowledge was desired was the characteristics of sprays from injection valves. While the fit between the spray and the combustion chamber is not of so much importance in the case of a low-speed, low-capacity engine, it is vital for the high-speed, high-capacity engine for aircraft. The spray was therefore to be studied with regard to its penetration, general shape, and atomization when injected into dense air.

The two outstanding problems in the obtaining of photographs of the spray formation, so the author stated, were the necessity of having a duration of exposure of about a millionth of a second and the production of photographic records, with this short exposure, at a rate of several thousand a second. Calculations show that it would be practically impossible to build a mechanically operated shutter which would give such a brief exposure. The only solution of the problem seemed to be to use the discharge of electrical condensers, eliminating shutters.

The next requirement was that the photographs of the spray be taken at a rate of several thousand per second. This necessitated the use of a number of condensers arranged so that they could be discharged at the required frequency. A series of such photographs was shown by lantern slides.

The end of the spray after cutoff appear somewhat like a corkscrew. This spiral appearance was probably caused by whirling of the oil drops which had passed around spiral grooves inside the valve, and seemed to continue after the oil had left the valve in spray form. The spray seemed to lose its motion in the last few pictures, especially at the nozzle, where the spray was practically hanging motionless in mid-air.

The penetration-time curves shown were plotted from data computed from measurements of the spray images on each. The spray volumes were computed by summation of the differential cylinders making up each spray.

When high-centrifugal sprays were injected into the atmosphere and into air at 200 lb. per sq.in., the reduction in the spray angle with the spray injected into dense air was about 40 per cent. This might well explain the failure of some centrifugal valves to operate successfully in an engine when the spray appeared well suited for the engine combustion chamber from observations made in the atmosphere. This decrease of spray-cone angle was characteristic of all centrifugal sprays.

In the second paper entitled "Experimental Combustion Chambers Designed for High-Speed Diesel Engines," Carlton Kemper, Langley Field, outlined the preliminary requirement of the high-speed fuel-injection engine problem and included an analysis of the cycles used in this type of engine, as well as a discussion of the effect of increasing speeds on the output of engines employing these cycles. The requirements of combustion chambers were set forth and results of experiments using three different types were outlined. Curves showing the performance of the engine when equipped with each of the special types of chambers also were shown.

A preliminary requirement of the high-speed fuel-injection engine problem, so the author stated, is the selection of a possible engine cycle to give high efficiencies without requiring excessive cylinder pressures. An analysis of the Otto or constant-volume cycle showed that its use with compression pressure sufficiently high to cause autoignition of the fuel presents difficulties, due to the resulting high explosion pressures. An analysis of the Diesel or constant-pressure cycle revealed that the cutoff ratio, which is defined as the ratio of the volume of the cylinder contents at cutoff to the clearance volume, to give the required mean effective pressure, would result in values greater than two. At high engine speeds, so the author held, this value of cutoff ratio would probably result in afterburning with excessive fuel consumption. The limitations of the above cycles had led to the adoption of the dual-combustion cycle, in which a small portion of the fuel charge burns at constant volume and the remainder at constant pressure. This cycle was approximated in several large, low-speed oil engines.

The type of combustion chamber having the lowest heat losses was that presenting the least surface area for a given volume. If this were the only requirement, it would lead to the design of spherical combustion chambers. For actual engine operation, however, there were other requirements, such as provision for turbulence, location of valves, simplicity, and ease of construction, which prohibited the use of a spherical combustion chamber.

Some of the successful commercial fuel-injection engines had obtained the necessary turbulence by reducing the cross-section of the combustion chamber for a short distance and then enlarging it into a bulb-shaped chamber containing the inlet and exhaust valves and the fuel-injection valve. The flow of gas through the connecting orifice produced a high degree of turbulence, and if the entire charge of air is forced into the bulb when the piston is on top center the combustion is usually good. A head of this type was used, having a bulb type of precombustion chamber.

A third type of combustion chamber was designed to give a high degree of turbulence within the pear-shaped bulb on the compression stroke and within the cylinder on the expansion stroke. The ratio of the volume of air in the bulb to the volume of air in the cylinder was approximately 1 when the piston was on top center. This head was tested with a compression ratio of 13.5 to 1, the compression pressure obtained in the engine being 450 lb. gage. The operation of this combustion chamber under all loads was smooth and regular. For full load operation at 1,800 r.p.m., the b.m.e.p. with a mechanical efficiency of 80 per cent was approximately 85.0 lb. The corresponding fuel consumption was 0.60 lb. per b.hp.-hr.

In conclusion it was stated that the performance of combustion chambers designed to give partial combustion and a controlled amount of turbulence, indicates that it is possible to increase the r.p.m. of the fuel-injection engine without encountering excessive explosion pressures.

In the discussions on these two papers O. E. Jorgensen, Worthington Pump & Machinery Corp., pointed out that in tests run on a solid-injection two-stroke-cycle Diesel he had found that the time lag in injection depended upon the volume of oil contained in the pump and oil piping and upon the actual timing of the injection.

Robertson Matthews doubted the value of a non-working cylinder and hoped that Langley Field would build a glass engine cylinder so that the entire combustion process could be examined. He believed that the combustion waves would be found to have wiped out the crest of the oil jet. The bulb design of combustion chamber would not prove flexible in high-speed operation.

Allan E. L. Cholton, of England, wrote that he doubted the usefulness of the bulb design and so had made use of a plain combustion chamber when designing the Beardmore high-speed Diesel. He had been able to get a record of 0.355 lb. per b.hp.-hr. at 1,023 r.p.m. using Anglo-Persian oil. In this engine an m.e.p. of 150 lb. had been obtained, using a supercharger. It would seem that these engines would have as long a life as slower speed units. He also favored constant-volume combustion even though this meant high pressure, but his experience indicated that this need not exceed 800 lb. per sq.in. On an engine with cylinders 8¼-in. bore by 12-in. stroke he had obtained 1,400 r.p.m. Weights of as low as 2 lb. per b.hp. could be obtained; after all, the real problem was the design of the fuel-handling mechanism.

A new high-speed indicator was described by Prof. H. M. Jacklin, University of Ohio, in his paper entitled, "Some Uses of the High-Speed Multi-Cylinder Indicator." The author stated that he, in association with C. P. Roberts, started the development of this indicator mechanism some years ago with the idea that a standard piston-type indicator could be used with high-speed units. His device consisted of a casing to which the standard indicator was attached and which had a mechanically operated poppet valve placed between the indicator and the pipe lines to the several engine cylinders.

This valve was opened for a small interval of time in each cycle of the engine, so that a small amount of gas or fluid might pass into or from the indicator cylinder to balance the pressure. The shaft of the instrument, to which is attached the connecting rod of the poppet valve, was ordinarily driven at the same speed as the crankshaft of the engine being tested through a suitable positive drive. Eight hundred cycles of a four-stroke-cycle engine were required to obtain a complete diagram. The resulting diagram showed a composite of two hundred cycles for each stroke of the engine. The pressures were built up and let down in small increments while the card was moved back and forth at slow speed. Thus, except where the pressures vary greatly from cycle to cycle, there was no inertia entering into the motion of the pencil mechanism of the low-speed indicator.

The cylinder of the indicator was ordinarily filled with a heavy lubricant to reduce the clearance and to provide an effective oil seal. The reduced clearance meant that only a minute amount of working fluid need enter or leave the indicator in order to balance the pressure, while an effective oil seal was necessary since the pencil must be held stationary between the instants that the valve is open.

In the discussion Carlton Kemper expressed his doubt of the utility of the indicator on high-speed units, inasmuch as the indicator diagram was a composite.

Edgar J. Kates, New York City, felt that the static friction might be too great to permit accurate pencil movement.

The author's statements were corroborated by R. F. Gagg, Climax Engineering Co., who stated that his company had used the machine with success. It had been found necessary to water jacket the tubes leading from the Diesel cylinders. It was also discovered that the use of too much lubricating oil made the indicator sluggish. In addition too long or too short a gas tube gave an erroneous diagram and slight errors in timing the indicator with the engine produced large errors in the diagram. He considered the instrument an improvement over the cumbersome optical apparatus.

Industrial Power Session

At the Thursday session on Industrial Power Walter H. Polakov presented a paper on "Management of Industrial Power from an Executive's Viewpoint." He stated that an executive should know what his power plant could do and why it failed to attain this standard. Of importance was the question of plant capacity, and if it was deficient, the ways of providing the needed capacity required careful study. This increased capacity to handle the load might be obtained by one of three methods—elimination of peak loads, purchase of power, and enlargement of the existing installation.

The executive should study, so he stated, the actual operating conditions and be able to put his finger on the sore spot, whether it be the poor operation, neglected maintenance, disgruntled men or an unusual load. Operating costs deserved special study, and these should be compared to a standard.

If the performance cost was greater than the cost of purchased power, it might pay to discard the plant unless the examination indicated that the plant had latent possibilities. While the financial outlook might justify the abandonment of the plant, due weight should be given the question of uninterrupted service.

In the comparison the executive must be certain that the power costs were actual. Quite often the power plant was not credited with the value of the heating and process steam.

To be able to find a complete answer to these problems, the executive would find that he would need a consulting engineer who definitely understood the industrial power plant situation.

In the discussion F. M. Gibson stated that there were various reasons why some managements did not maintain records. Until two or three years ago, one read very little of the many excellent industrial power plants that were being built. The central station

introduced most of the new equipment and methods, and the technical press found greater news value in those stations, and most articles dealing with industrial power plant were stressing the great waste of fuel caused by inefficiency and mismanagement. It was not unreasonable to think that some managements suffered an inferiority complex in regard to their power plants. To many, their power plant was a necessary evil; they did not understand its operations and failed to give it the same consideration that was given to other departments.

Managements sometimes failed to keep proper records because the situation had not been properly placed before them by the engineers. Their reports were not stated clearly nor in a convincing way. Managements required that opinions and estimates be supported with a reasonable amount of proof.

Some managements believed that the two items, namely, pounds of fuel and cost of fuel per unit of product, were sufficient. In such cases, when an increase in these unit figures occurred, it was impossible to tell whether the inefficiency had taken place in the power plant or in the production department.

The failure to install an adequate system of records of performance and cost was not confined to smaller plants but existed in many large plants. Less than a year ago an industrial plant consuming up to 700 tons of coal a day had installed for the first time a system to determine the efficiency of operation as well as the cost of power.

A. D. Bailey, Chicago, complimented Mr. Polakov on the excellent graphic charts he had presented. He believed that as the industrial power plant became larger the plant engineer would be given more consideration, since the power costs would then be a large item in the budget.

John Lawrence, New York City, agreed that too seldom did the factory management get together with the plant engineer. Neither knew the other's problem, and frequently plant extensions were made or contemplated that were not justified.

A paper on "Evaporators for Boiler Feed Makeup" was read by W. L. Badger, Ann Arbor, Mich. This will be published in a future issue of *Power*.

Refrigerating Engineers Hold Spring Meeting

THE fourteenth Spring Meeting of the American Society of Refrigerating Engineers was called to order by its president at White Sulphur Springs, W. Va., May 23. Due probably to the attractions of this resort and possibly to the superior character of the papers the meeting was more largely attended than is usual.

After various purely business matters had been disposed of, several standing committees gave their reports.

The Committee on Pipe, Valves and Fittings announced that physical dimensions for ammonia fittings up to 3½ in. had been tabulated. Emphasis was placed upon the fact that various physical and chemical characteristics of the fitting materials had not been investigated. While the committee was working with a similar committee of the American Society of Mechanical Engineers, it was felt that the manufacturers' subcommittee should work out part, if not all, of the problem.

The Committee on Welding had little progress to report, but indicated that it was working in conjunction with committees of the A.S.M.E. and of the Welding Society.

Code of Ethics Adopted

Upon the favorable report of the Code of Ethics Committee, the Society voted to adopt the code of the American Society of Mechanical Engineers provided the latter society permitted.

The report of the Educational Committee, of which Prof. A. J. Wood, Pennsylvania State College, is chairman, was read by Dean Sackett of State College. Attention was called to the data book issued by the Society, covering information on various refrigerating media. The committee held that drafting-room procedure and engineering symbols should be taken up and as a future activity of the Society stressed the need of refrigerating courses in the engineering schools.

Mr. Hiller, Carbondale Machine Co., stated that the Ice Manchinery Manufacturers' Association felt that the real need was a better grounding in the fundamentals of physics and chemistry. With this foundation the college graduate would be prepared to take post-graduate work in refrigeration.

In reply Dean Sackett stated that undergraduates should study refrigeration just as they did steam engineering, and then they could the more easily determine if this branch of engineering held any interest for them.

Corrosion Tests

The Committee on Corrosion, through Prof. R. P. Russell, Massachusetts Institute of Technology, gave details as to corrosion tests made since the winter meeting. These tests consisted of two parts—those performed in the laboratory and others carried out in the plants. For a corrosion preventive with calcium magnesia brine, it was found that sodium bichromate reduced the corrosion to but 15 per cent of the rate with untreated brine, for both black and galvanized pipe.

The bichromate was added in the proportion of 125 lb. per 1,000 cu.ft. of brine. The brine should be made slightly alkaline. Attention was called to the trouble experienced in case of open tanks from itch appearing on the workmen's hands where care was not exercised in washing. Consequently, disodium phosphate at the rate of 125 lb. per 1,000 cu.ft. was tested. It was found that the life of the treatment was short; in 60 days one-half the original dose must be added, making the cost approximately $30 per year per 1,000 cu.ft.

Slushing oils were studied, and one composed of sperm oil, vaseline and zinc dust was found most effective.

For closed-type condensers sodium silicate seemed to be the best corrosion preventive, but for open systems where the water is wasted, the cost is too high. None of the trade brands stood up very long, red lead appearing to better advantage. Stainless-steel condenser pipe showed no ill effects even where untreated water was used. In testing for the drop in heat transfer rate, it was found that all the various coatings caused a drop of 50 to 75 per cent; likewise a $\frac{1}{32}$ in. coat of rust halved the rate.

Slime on atmospheric condensers was found to increase the temperature difference between the water and ammonia from 7½ to 15 deg. F.

In a paper on "Physical and Chemical Properties of Methyl Chloride," Prof. H. T. Macintire, C. S. Marvel and Stanley G. Ford, of the University of Illinois, reported a study of the comparative properties of a number of refrigerating media. It was their opinion that for fractional tonnage machines methyl chloride was quite superior. Tests were made to settle the moot question of decomposition, but even at 800 deg. F. no signs of such action appeared. Corrosion did not appear during a 40-hour heating to 175 deg. F. The problem of oil in the coils was examined, but it was found that the oil separated from the methyl chloride although the two are miscible. The presence of oil, however, does increase the condenser pressure and has the effect of increasing the boiling temperature in the evaporator. The refrigerant lowers the viscosity of the oil, but not enough to make it useless as a lubricant.

In addition, the authors felt, the low compressor volume per unit of duty and the moderate pressures made this medium suitable for small refrigerating machines. A heat diagram covering methyl chloride was presented.

In the discussion Prof. L. A. Phillips, University of Michigan, took exception to the term "Thermal Potential" used to express the heat added or abstracted during a change in state. It was felt that "Total Heat" being in general use was preferred for all charts. Attention was also called to errors in certain of the tables given in the paper.

Air Conditioning

At the Monday evening session L. L. Lewis, Carrier Engineering Co., presented a paper on "Air Conditioning in the Theater." This consisted of a discussion of the relative cost of air conditioning and of ventilating equipment

for a theater of an assumed capacity of 1,000 persons. According to the author the air-conditioning apparatus would cost $32,000, while ventilating equipment could be installed for $12,000. Total costs for the former were estimated to be 3.66c. per seat per day, a total of $13,235 yearly and for the ventilating equipment $7,340 per year or 2c. per seat per day. Stress was placed on the necessity of removing and deodorizing the air as well as cooling it.

In his paper on "Household Refrigerating," L. A. Phillipp gave details of capacity tests run on a Kelvinator machine.

This was a standard unit, using a 1½-in. bore by 1⅛-in. stroke compressor, driven by a ¼-hp. repulsion-type motor. The tests revealed that the three factors of largest significance in increasing the over-all efficiency of the small refrigerating machines are the efficiency of the motor, the mechanical efficiency of the compressor and its volumetric efficiency. The desired mechanical efficiency may possibly be obtained with a smaller compressor operating at a higher speed. The volumetric efficiency can be bettered through a reduction in head pressure, brought about by an improved heat transfer in the condenser.

The Platen-Munters absorption system, as developed by the Servel Corp., was dealt with by F. E. Sellman in a paper entitled "The Gas-Fired Refrigerator." This was in the main a description of the apparatus, similar to an outline published in *Power* for Nov. 23, 1926, p. 767. The author stated that tests showed that the apparatus required from 1.5 to 3 cu.ft. of city gas per hour and that the machine will operate with condenser water of 90 deg. F. The advantage of the absorption machine was stated to be its noiselessness, there being no moving parts. About 1,000 of these units were in operation in the Eastern States, and contrary to expectations the water coil did not scale and hydrogen did not escape.

Characteristics of Centrifugal Pumps

The Monday evening session was devoted to the subject of household ice machines as was also the major portion of the Tuesday meeting. However, at the latter session H. J. Meeker, Worthington Pump & Machinery Corporation, presented a paper entitled "Characteristics of Centrifugal Pumps," which evoked general interest. He stated that the shape of the characteristic curve depended upon the head, the capacity and the pump. The form of the vane also, had an important influence, the vane of the usual pump being made with a backward angle at both the suction and discharge ends. With increased capacity the velocity at the eye of the impeller was increased. If the suction lift was high, say 25 ft., the amount of pressure to create the needed velocity was limited, so high suction compelled a decreased capacity. It is the practice of pump builders to guarantee results only when the suction lift is not over 15 ft.

The advantage of using two pumps in place of one on installations where the demand varies was largely overlooked. The excess head developed by throttling the discharge to half capacity was considerable and the energy reappeared as heat in the liquid handled. The situation could be corrected by using a pump with a flat characteristic curve. But if the head was underestimated this type of pump would be a failure. A pump that develops a rather steep head-capacity curve at the point of normal operation is considered best as it gives a smaller reduction of capacity at increased pressures.

The opinion was expressed that variation in brine density might affect the power requirements. Allowance must be made when designing pumps to handle viscous fluids.

Corrosion was also more pronounced when pumping brines and it was felt that higher speed bronze pumps could be sold at about the same price as a slow-speed cast iron brass-fitted pump.

The author pointed out that pumps should be set on a good concrete foundation. The pump and motor should be aligned, for a flexible coupling can take care of but slight misalignment. Pipe flanges should not be forced into contact as this places a strain upon the pump. Other details of installation were given.

H. B. Hill inquired as to the facts about the influence of viscosity and George A. Horne stated that in a heat balance no extra heat due to viscosity change had been discovered.

Carbon Dioxide Machines

In his paper "Factors Governing the Liquefaction of CO_2," J. C. Gossmann, at the Wednesday session outlined several of the problems confronting the refrigerating man dealing with CO_2.

In order to liquefy ammonia we were accustomed to determine its temperature of saturation with reference to the temperature of the water as fixed by local conditions, its available quantity and the water pressure necessary for ample circulation—all of these in turn designated a definite pressure.

With carbon dioxide, however, the case was not so simple, so he stated. We had the same definite temperature of saturation with pressure to correspond, yet when applied in the same manner as with ammonia the temperature of the condensate leaving the condenser was generally found to be considerably higher than the corresponding saturation temperature would lead one to expect. This deviation from the desired condition naturally varied with the condenser type, condensing surface and the quantity of water employed. It would approach a predetermined temperature most closely with the best condenser type and reach a disappointing figures when the condensing means were less efficient. With ammonia it was at least possible to obtain a condensate temperature but slightly higher than the temperature of the water leaving the condenser when the pressure corresponded. This is not so with carbon dioxide. A pressure corresponding to a certain temperature of saturation never provided a condensate of equal temperature; it approached the same only at very low condensing temperature when surfaces and water quantities were ample.

The critical temperature of carbon dioxide at 88 deg. was at a point when, with 86-deg. temperature of the condensate, the liquid condition began to disappear, attended by a complete loss of latent heat.

Apparently, then, the use of carbon dioxide at and above this temperature would become non-effective for refrigerating purposes. In practice the apparent loss of latent heat did not at all detract from its value as a refrigerant. In fact it retained its refrigerating effect nearly undiminished and of practically the same energy, whether below or above the critical temperature, with or entirely without latent heat, at least so far as it pertained to the condensate leaving the condenser.

Above the critical point the new Bureau of Standards tables left one entirely in the dark, just as all its predecessors had. Throughout its range—that is, from the triple point to the critical—the saturated temperature and corresponding pressure was entirely theoretical and was of little use in the most important region met in the practical field, except at temperatures below 80 deg., where the temperature of the condensate corresponded more nearly with the pressure. Even there, satisfactory practice required a pressure at least several degrees higher than the theoretical saturation point. This seemed to be due to the fact that carbon dioxide did not change into liquid with an increase in pressure as readily as did ammonia. In fact, the pressure was always higher than that corresponding with saturation in order to obtain a liquid temperature corresponding with the latter.

It was therefore necessary, so the speaker claimed, to increase the actual working pressure to at least the 1,100-lb. line.

The aim in the improvement of the carbon-dioxide system, it was stated, therefore must be the reduction in the horsepower per ton. Two means were available—the employment of the dual effect, and the use of an expansion cylinder. The first had been successfully developed, while the second remained to be tried and tested.

Advantages of Dual Compression

A comparison on an equal basis between dual and single compression from the power viewpoint showed the relation of 1.33 to 1.8 hp. per ton, or 0.74, revealing an advantage of the dual method over the single of 26 per cent in horsepower. From a capacity point of view the advantage is larger.

The best results obtained in a series of over 100 tests made last summer had shown an increase in the capacity of the same machine with conditions alike up to 65 per cent and a decrease in the horsepower per ton up to 26 per cent. It was certain, however, that these results could be improved.

A positive requirement in the dual-effect operation was the employment of reliable automatic - control valves. Without these results would remain entirely uncertain.

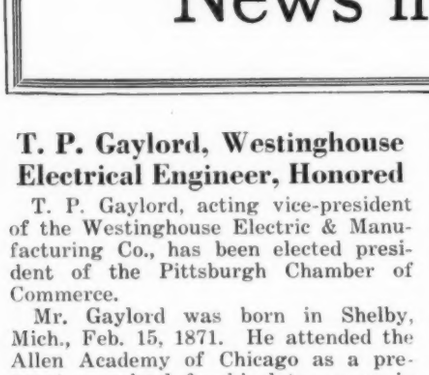
In the discussion Prof. H. J. Macintire pointed out that a CO_2 system held air as did an ammonia system, and the partial pressure due to this air was the reason for the discrepancy in the relation between the pressures and the saturated temperatures.

News in the Field of Power

T. P. Gaylord, Westinghouse Electrical Engineer, Honored

T. P. Gaylord, acting vice-president of the Westinghouse Electric & Manufacturing Co., has been elected president of the Pittsburgh Chamber of Commerce.

Mr. Gaylord was born in Shelby, Mich., Feb. 15, 1871. He attended the Allen Academy of Chicago as a preparatory school for his later years in university training, which were devoted



T. P. Gaylord

to study at the University of Michigan, from which he was graduated with the degree of electrical engineer. He secured a degree also from the Armour Institute of Technology in 1895.

WITH WESTINGHOUSE IN 1899

When the Chicago World's Fair was opened, Mr. Gaylord went to work for the fair company as engineer of underground construction, and he continued in that capacity from 1892 to 1893. Following the close of the World's Fair, Mr. Gaylord became assistant professor of electrical engineering at the Armour Institute, Chicago, serving there from 1893 to 1898. He was engineer of the Chicago Edison Co. from 1898 to 1899 and took his first job with the Westinghouse Electric Co. in July, 1899. In 1902 he was appointed district manager, with offices in Chicago, which position he occupied until his present appointment in August, 1914.

Mr. Gaylord is a director in the Pittsburgh Chamber of Commerce, a director and member of the executive committee of the Pennsylvania State Chamber of Commerce, a member of the American Institute of Electrical Engineers, Chamber of Commerce of the United States, Duquesne Club of Pittsburgh and the Pittsburgh Athletic Club.

N.E.L.A. Fiftieth Convention at Atlantic City, N. J. June 6-10

First General Session, June 7

Address of President R. F. Pack, Northern States Power Co.

"Our Industry," Gerard Swope, president, National Electric Manufacturers Association, Honorable Dwight F. Davis, Secretary of War.

"Relation of the Electric Light and Power Industry to Labor," William Green, president of the American Federation of Labor.

Engineering Session, June 7

Committee Reports

C. F. Hirshfeld, chairman Engineering National Section, Detroit Edison Co.

Electrical Apparatus Committee, H. R. Woodrow, chairman, Brooklyn Edison Co.

Engineering Administration Committee, A. C. Marshall, chairman, Detroit Edison Co.

Hydraulic Power Committee, H. L. Doolittle, Southern California Edison Co.

Today's Science and Tomorrow's Engineering, L. A. Hawkins, General Electric Co.

Meter Committee, A. G. Turnbull, chairman, Commonwealth Edison Co.

Prime Movers Committee, A. D. Bailey, chairman, Commonwealth Edison Co.

Water Power Development.

Another American Firm Gets Large Russian Contract

An attempt to place Russia among the industrial nations is seen in the decision of the Soviet government to initiate a complete survey of its iron and steel industry. This will cover much new construction as well as rehabilitation of existing plants and will include the power problems.

For this work a five-year contract has just been closed with the Freyn Engineering Co., of Chicago, through its president, Henry J. Freyn, who is now abroad, covering consultation, plans and supervision of construction. It is planned to employ American machinery to a large extent.

This is the second large consulting engineering contract to be awarded by the Soviet government to American engineering firms, the first being the Dnieper River project, which was awarded recently to Col. Hugh M. Cooper now engaged on that project.

New York N.E.L.A. Holds Safety Rally

The fourth annual safety rally of the engineering division of the Metropolitan Section of the National Electric Light Association was held in New York City, Friday, May 20, 1927.

Said to have been the largest rally of this nature held anywhere in the country, the meeting overflowed the capacity of the Columbus Auditorium. Ralph Neumuller, chairman of the Metropolitan Section, introduced John W. Lieb, vice-president and general manager of the New York Edison Co., who acted as chairman for the evening. Talks were given by a number of prominent New York public utility men, among whom were Frank W. Smith, vice-president and general manager of the United Electric Light & Power Co.; James A. Hamilton, commissioner, New York State Department of Labor, and Arthur Williams, vice-president of the New York Edison Co.

Trophies were presented by Mr. Lieb to those companies and departments having excelled in the prevention of accidents for the period from July, 1926, to January, 1927. E. H. Rosenquest, president of the Westchester Lighting Co. and the Bronx Gas & Electric Co., presented prizes for the winners of the safety poster contest. Then followed an hour of entertainment.

INCREASE IN INDUSTRIAL FATALITIES

The rally was supported by employees of the gas and electric companies of the Metropolitan New York district, comprising New York, Bronx, Westchester, Queens and Richmond Counties, who were interested in the promotion of universal accident prevention.

In spite of the excellent work being done by the Safety First Committee of the N.E.L.A. fatal industrial accidents in New York State have shown an increase from 346 in 1923 to 441 during the year 1926. It was brought out that for every one dollar paid to employees as compensation for accidents, the loss of time due to the accident cost the employer four dollars.

New Power Construction for North Dakota

Plans for new power houses and extensions of high voltage transmission lines, to be constructed at a cost of $1,100,000, have been filed with the North Dakota state railroad board.

A new power plant on the Bois De Sioux River, near Wahpeton, is contemplated by the Ottertail Power Co.

Boiler Manufacturers Gather for Annual Convention

The thirty-ninth annual convention of the American Boiler Manufacturers Association is now in session at the French Lick Springs Hotel, French Lick, Ind.

With the registration of attending members over, the meeting was called to order the morning of May 30, when George W. Bach, president, spoke on the commercial development of the boiler industry. Reports of standing and special committees were then presented. In the afternoon the spring golf tournament was held. In the evening Prof. S. W. Parr, University of Illinois, spoke on caustic embrittlement, and W. H. Rastall, of the Department of Commerce, Washington, D. C., on the possibilities of the boiler export business.

During the afternoon of May 31 members and the attending ladies devote themselves to sports and in the evening to an informal banquet.

"The Use and Growth of Steel Boilers for Heating Purposes" is a topic scheduled to feature the June 1 session. Reports of the auditing and nominating committees will be followed by the election and installation of officers.

Tri-State Power Meeting Offers Varied Program

A power conference, with the Erie Local Section of the American Society of Mechanical Engineers as host, will be held in that city June 3 and 4, when the Buffalo, Cleveland and Pittsburgh Sections will co-operate in what is known as the Tri-State Power Meeting.

Three papers are scheduled for presentation, each of outstanding value. The program will open with registration at the Hotel Lawrence, Friday morning, June 3, when there will be short addresses of welcome at the Masonic Temple by the Mayor of Erie, the president of the Chamber of Commerce, and the president of the Manufacturers' Association. Immediately after this the technical sessions will begin.

Will Inspect Erie Plants

The first paper will be "Modernization of Industrial Power Plants," by Major Clarence G. Spencer, Baker & Spencer, Inc., New York City. The other paper of the morning will be "Conditions and Effects of Electric Drive as Compared with Older Methods," by R. H. Rogers, industrial engineering department, General Electric Co., Schenectady, N. Y. This paper will be illustrated by a number of slides.

The afternoon will be given over to inspection tours through the industrial plants of Erie, including those manufacturing writing paper, boilers, engines, power-plant equipment, mechanical rubber goods, electric motors, transformers, and electric locomotives. In the evening a banquet will be held at the Masonic Temple Hall, at which Fred R. Low, editor of *Power*, will speak.

On Saturday a technical paper will be read on "Some Fundamental Considerations in the Design of Boiler Furnaces," by Prof. W. J. Wohlenberg and F. W. Brooks, of the Sheffield Scientific School of Yale University.

Directly after the conference, about 10:30 a.m., a boat ride on Lake Erie is planned. This will enable the visitors to view the Erie port facilities. There will be a fish fry on the peninsula, and the rest of the afternoon will be given over to sports and bathing.

Special provision has been made to entertain the ladies at luncheon on Friday at the Hotel Lawrence.

A.I.E.E. Elects Gherardi to Presidency—Growth Seen

Bancroft Gherardi, vice-president and chief engineer of the American Telephone & Telegraph Co., New York City, was elected president of the American Institute of Electrical Engineers at the annual business meeting held in the Engineering Societies Building, New York City, May 20.

Other officers elected were: Vice-Presidents—J. L. Beaver, Bethlehem, Pa.; C. O. Bickelhaupt, Atlanta, Ga.; O. J. Ferguson, Lincoln, Neb.; E. R. Northmore, Los Angeles, Calif.; A. B. Cooper, Toronto, Ont. Managers—F. C. Hanger, East Pittsburgh, Pa.; H. P. Liversidge, Philadelphia, Pa.; E. B. Meyer, Newark, N. J. National Treasurer—George A. Hamilton, Elizabeth, N. J. (re-elected). These officers, together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning August 1: C. C. Chesney, Pittsfield, Mass.; M. T. Pupin, New York City; H. M. Hobart, Schenectady, N. Y.; B. G. Jamieson, Chicago, Ill.; George L. Knight, Brooklyn, N. Y.; H. H. Schoolfield, Portland, Ore.; A. E. Bettis, Kansas City, Mo.; John B. Whitehead, Baltimore, Md.; J. M. Bryant, Austin, Tex.; E. B. Merriam, Schenectady, N. Y.; M. M. Fowler, Chicago, Ill.; H. A. Kidder, New York City; E. C. Stone, Pittsburgh, Pa. I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; F. J. Chesterman, Pittsburgh, Pa.

The annual report of the board of directors, presented at the meeting, showed a net increase in the membership during the year of 186, the total membership on April 30 being 18,344. In addition to the three national conventions of the Institute and five regional meetings, there were 1,273 meetings held by the local organizations in the principal cities and educational institutions in the country.

Vermont Power Properties Purchased by Foshay

W. B. Foshay Co. has purchased all properties and assets of the Clyde River Power Co., operating in northern Vermont, according to announcement May 18 from the offices of the company.

This property furnishes electric service to seven growing towns, one of which is Richmond, where there are furniture and veneer factories. John J. Flynn, from whom the properties were purchased, bought them last December; they include the hydro-generating plant and transmission lines, with some of the best power and water sites in the state. There are several reserve steam plants maintained all the time for emergencies.

To Study Boiler Feed Water at Water Works Session

The forthcoming session of the Joint Research Committee on Boiler Feed-Water Studies will be held in connection with the annual convention of the American Water Works Association at the Hotel Sherman, Chicago, June 6 to 11.

The conference of Committee No. 19, Boiler Feed-Water Studies, of which Sheppard T. Powell is chairman, will be devoted to seven papers, four of which relate to feed-water treatment as applicable to stationary practice and the remaining three to railroad practice.

The meeting scheduled for June 8, Wednesday, embraces the presentation of "Progress Report of the Activities of the Boiler Feed-Water Studies Committee for 1926 and 1927," by Sheppard T. Powell; "Priming and Foaming of Boiler Waters," by C. W. Foulk; "Boiler Feed-Water Treatment from a Manufacturer's Viewpoint," by J. B. Romer, and "Zeolite Water Treatment in a Large Central Heating Plant," by Alfred H. White, J. H. Walker and Everett P. Partridge.

In the afternoon "The Value of Boiler Water Treatment to the Mechanical Department," by J. F. Raps, will be offered.

Through this Joint Research Committee on Boiler Feed-Water Studies, six national technical organizations are co-operating actively in a study of the various processes employed in the purification of feed water in steam power plants and on railroads. This research is being carried on to determine the fundamental principles underlying certain phenomena which take place in steam boilers.

The committee is sponsored by the American Boiler Manufacturers' Association, American Railway Engineering Association, the American Water Works Association, the National Electric Light Association, the American Society for Testing Materials, and the American Society of Mechanical Engineers, and has been subdivided into nine subcommittees and an advisory committee.

Each subcommittee is collecting data relating to the subject assigned to it, and has been requested to compile and submit yearly reports. After review by the advisory committee, they are presented for publication in the journals of the organizations participating in these studies. Plans are being made to have the reports for 1927 presented at the A.S.M.E. Annual Meeting in December.

Personal Mention

A. L. Menzin is now with the Andrews-Bradshaw Co., Pittsburgh, Pa., in the capacity of director of research. Mr. Menzin has had extensive designing, construction and re-

search experience on steam power plant equipment, having been for some years chief engineer of the Tracy Engineering Co., and prior to that, consulting engineer with the Edge Moor Iron Co., manufacturer of Edge Moor boilers. Mr. Menzin is a graduate of the University of California, class of 1907.

R. N. Robertson has joined the Andrews-Bradshaw Co., Pittsburgh, Pa., manufacturers of the Tracyfier, as chief engineer. Mr. Robertson becomes associated with this company following a period of 20 years' service with the American Smelting & Refining Co. His work with that company comprised all branches of power-plant engineering, and special technical problems concerning the flow of gases, smoke determinations, and as supervisor in charge of all power and mechanical work at all plants in the Western division of the American Smelting & Refining Co. Mr. Robertson is a Cornell man, class of 1905.

Business Notes

The Amtorg Trading Corp., 165 Broadway, New York City, the principal organization in American-Soviet trade, is celebrating the completion of its third year of operations.

The Foote Bros. Gear & Machine Co. announces that E. L. Parsons, formerly district manager for the Ramsey Chain Co., Boston, has recently joined the sales force of the company, and has been appointed district representative for the State of Wisconsin and northern Illinois, with headquarters at 49 E. Wells Street, Milwaukee.

The Stephens-Adamson Manufacturing Co., manufacturer of conveying transmission and screening machinery and S-A belt conveyors, Aurora, Ill., announces the opening of a plant at Belleville, Ontario. From this branch factory there will be supplied the entire S-A conveying machinery line for the Canadian trade, in addition to a general export business to foreign markets.

The Lincoln Electric Co., Cleveland, Ohio, announces the appointment of the Wade Engineering Co., 1855 Industrial St., Los Angeles, Calif., as distributor of Lincoln products in California. This company maintains a branch at 69 Webster St., Oakland, Calif., both main offices and branch carrying a stock of Lincoln "Linc-Weld" motors and "Stable-Arc" welders, as well as service parts. The Los Angeles branch is in charge of Henry N. Wade, who is also president of the company.

Trade Catalogs

Anthracite Dumping Grate, Type No. 4-A — The McClave-Brooks Co. gives special attention to its Type No. 4-A anthracite dumping grate for high efficiencies from small sizes of anthracite in a short but well illustrated descriptive catalog.

Coming Conventions

American Association of Engineers. Annual convention, Tulsa, Okla., June 6-8; M. E. McIver, 63 East Adams St., Chicago.

American Boiler Manufacturers Association. Annual meeting at French Lick Springs Hotel, French Lick, Ind., May 30-June 1.

American Institute of Electrical Engineers. F. L. Hutchinson, secretary, 33 West 39th St., New York City. Summer convention at Detroit, Mich., June 20-24 inclusive; Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Order of Steam Engineers. Annual convention, Moose Hall, 1314 North Broad St., Philadelphia, Pa., June 13-16; J. E. Burke, 1821 So. Ringgold St., Philadelphia.

American Society of Civil Engineers. George T. Seabury, secretary, 33 West 39th St., New York City. Annual convention at Denver, Col., July 13-15.

American Society of Mechanical Engineers. Calvin W. Rice, secretary, 33 West 39th St., New York City. Tri-State Power meeting at Erie, Pa., with the Buffalo, Cleveland and Pittsburgh sections co-operating, June 3 and 4.

American Society of Refrigerating Engineers. Western meeting at White Sulphur Springs, W. Va., May 23-25, in conjunction with the Spring meeting of the A.S.M.E.; W. H. Ross, 35 West 39th St., New York City.

American Society for Testing Materials. Annual convention at French Lick Springs Hotel, French Lick, Ind., June 20-24; J. K. Rittenhouse, secretary, 1315 Spruce St., Philadelphia, Pa.

American Water Works Association. W. M. Niesley, assistant secretary, 170 Broadway, N. Y. Annual convention Hotel Sherman, Chicago, June 6-11.

Association of Iron and Steel Electrical Engineers. Annual convention at Pittsburgh, Pa., June 13-18, inclusive.

National Association of Practical Refrigerating Engineers. Annual convention probably in November; E. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Association of Stationary Engineers—Annual convention at Ambassador Hotel, Los Angeles, Calif., Aug. 22-27; John Topman, secretary, convention committee, Ohio State annual convention in Memorial Hall, Lima, Ohio, June 16-18; P. H. Grigsby, secretary, Lima, Ohio. New England States convention at Portland, Me., June 17-18; Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass., Hartford meeting June 24-25, business sessions Saturday morning, aviation flight and banquet. Plainfield, N. J., meeting at Academy Hall, June 3-5.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Nashville, Tenn., June 14-16 inclusive.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Convention at Atlantic City, June 6-10; exhibition, June 4-10.

Universal Craftsmen Council of Engineers. Thomas H. Jones, secretary, 33 Linden Ave., Cherrydale, Va. Annual convention at Buffalo, N. Y. Aug. 2-6.

Anthracite Stokers Type "M-A"—The McClave-Brooks Co., Scranton, Pa., issues at this time a catalog on the type "M-A" of the anthracite stokers manufactured by the company. This stoker consists of the combination of the features or elements of a mechanical stoker with the latest form of hand firing or stoking, with a forced undergrate draft. The number of moving parts is reduced to an absolute minimum and the entire grate surface is active, with no dead air space, accord-

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	May 23 1927
Pool 1	New York	$2.50@$3.00
Smokeless	Boston	1.70
Clearfield	Boston	1.60@ 1.85
Somerset	Boston	1.75@ 2.00
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	1.75@ 2.00
Pittsburgh	Pittsburgh	2.00@ 2.20
Pittsburgh gas slack	Pittsburgh	1.45@ 1.60
Franklin, Ill	Chicago	
Central, Ill	Chicago	
Ind. 4th Vein	Chicago	
West Ky	Louisville	1.40@ 1.60
S. E. Ky	Louisville	1.50@ 1.75
Big Seam	Birmingham	1.50@ 1.90
Anthracite Gross Tons		
Buckwheat No. 1.	New York	2.50@ 3.00
Buckwheat No. 1.	Philadelphia	2.50@ 3.00
Birdseye	New York	1.40@ 1.60

FUEL OIL

New York—May 26, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal.; 36@40 deg., 5¾c. per gal. f.o.b. Bayonne, N. J.

St. Louis—May 17, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75 per bbl.; 28@30 deg., $1.80 per bbl.; 30@32 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4.116c. per gal.; 38@40 deg., 5.23c. per gal.

Pittsburgh — May 17, f.o.b. local refinery; 30@34 deg., fuel oil, 6c. per gal.; 36@40 deg., fuel oil, 6¼c. per gal.

Philadelphia — May 20, 27@30 deg., $2.25@$2.31 per bbl.; 13@19 deg., $1.75 @$1.81 per bbl.

Cincinnati — May 24, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—May 21, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., 97½c. per bbl.; 26@30 deg., $1.05; 30@32 deg., $1.12½.

Boston—May 23, tank-car lots, f.o.b. 12@14 deg. Baumé, 4¼c. per gal.; 28@32 deg., 5.8c. per gal.

Dallas—May 19, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

ing to the catalog. Installation views, sectional parts and blueprint adaptations are included in the 19 illustrations.

CO_2 Electrical Meters—The Leeds & Northrup Co., manufacturer of electrical measuring instruments, Philadelphia, Pa., has put out Bulletin No. 781, which is No. 5 of the Power Plant Series of catalogs issued on the products of the company.

Pulverburners—The Illinois Stoker Co., Alton, Ill., in an illustrated catalog describes the Pulverburner, a complete mechanism of the unit type for the firing of powdered coal. Operation and construction details, elucidated at length, are supplemented by sectional views and charts of performance.

Leak Sealing Equipment—The Furmanite Corp., Newport News, Va., has devoted an illustrated catalog to the exposition of Furmanite leak-sealing equipment and compound, through the application of which leaks in pipes and containers are sealed without the necessity of first shutting off the pressure or current. Briefly stated, the operation consists of forcing the compound, which is put up in cartridge form to become semi-fluid when it is first heated, by means of suitable pressure guns into the leak under a greater pressure than the pressure of the gas or fluid inside the pipe or container, and confining the semi-fluid compound in the leak by means of baffles, clamps and other appliances, until it hardens.

Ventilators—The Burt Manufacturing Co., Akron, Ohio, manufacturer of ventilators, oil filters, exhaust heads, etc., describes its ventilating equipment designed for power plants, paper mills, metal-working shops, railroad buildings, petroleum plants, warehouses, and public and private non-industrial buildings.

Three-Stage Centrifugal Steam Separators — The Hagan Corp., combustion and chemical engineers, Pittsburgh, Pa., have published an illuminating and very interesting bulletin entitled "Clean Dry Steam and How to Secure It," in connection with the Hagan three-stage centrifugal steam separators manufactured by the company. These are made in six sizes, 3-in., 4-in., 6-in., 8-in., 10-in. and 12-in., and in five different types, ET, ES, EL, ER and EST, as shown in special illustrative figures. For steam pressures up to 250 lb. semi-steel construction is furnished and for higher pressures an all-steel construction. Dimensions of all types and sizes of the Hagan steam separator are given in a table.

Forced-Draft Chain-Grate Stokers—The McClave Brooks Co., Scranton, Pa., has recently issued a descriptive and illustrated catalog on the McClave forced-draft chain-grate stoker for all grades of anthracite, coke breeze and mixtures. The grate is composed of a chain of links with approximately one-third of the grate under fire at one time, and as the links permit an absolutely flat surface, there is no chance for them to extend into the fire. The green fuel is fed uniformly to the front end of the grate, then it passes through the actual combustion zone and continues to travel until it reaches the rear end of the grate, where it is entirely burned out and the ash falls over the rear end into the ashpit. Many new features have been added, including replaceable links, mechanical sifting removers, and an entirely new design of spur gear and rachet drives, all of which are designed to give higher efficiencies with lower maintenance costs. Blueprint adaptations of the stoker enhance the value of this important catalog.

New Plant Construction

Calif., Merced—R. J. Stempel, et al., c/o J. C. Hladik, Monadnock Bldg., San Francisco, Archt., is having plans prepared for the construction of a 7 story hotel at 20th and M Sts. Estimated cost $650,000.

Calif., San Francisco—Methodist Book Concern, 5 City Hall Ave., is having preliminary plans prepared for the construction of a 23 story hotel and church building at McAllister and Leavenworth Sts. Estimated cost $2,000,000. L. P. Hobart, Crocker Bldg., is architect. T. Ronneberg, Crocker Bldg., is engineer.

Calif., Williams—City, I. A. Fouch, Clk., will soon receive bids for waterworks improvements including pumping plants, 100,000 gal. tank on tower, etc. C. E. Sloan, Santa Fe Bldg., San Francisco, is engineer.

Colo., Rye—E. E. Jeter, awarded contract for the construction of a waterworks system including pumping plant, mains, etc. to T. Mishou, Pueblo.

Ill., Chicago—J. A. Bidderman, 10 South La Salle St., awarded contract for masonry, etc. for an 8 story hotel at 4539-4541 Sheridan Rd. Estimated cost $850,000.

Ill., Chicago — Coffey & McKeown, 310 South Michigan Ave., awarded contract for the construction of a 23 story office and stores building at Wells St. and Wacker Dr. to Dilks Construction Co., 160 North La Salle St. Estimated cost $4,000,000. Nine elevators, etc. will be installed.

Ill., Chicago—Chicago Eye, Ear, Nose & Throat Hospital, Washington and Franklin Sts., awarded contract for the construction of a 10 story hospital to McLennan Construction Co., 307 North Michigan Ave. Estimated cost $700,000. Steam heating system will be installed.

Ill., Chicago—Koclanes Bros., 529 North Clark St., awarded contract for the construction of an apartment building at Austin Ave. and Madison St. to Finlayson Bros., 137 North Clark St. Estimated cost $700,000.

Ill., Chicago—B. Leo Steif & Co., 307 North Michigan Ave., Archts., will soon receive bids for the construction of a 16 story apartment at Elm and North State Sts. for S. Cole, 307 North Michigan Ave. Estimated cost $2,000,000.

Ill., Kankakee—J. J. Redding & Co., 10 North Clark St., awarded contract for masonry, etc. for a theatre, stores and office building at Dearborn Ave. and Merchant St. Estimated cost $750,000.

Ky., Lakeland—State Bd. of Charities & Correction, Frankfort, plans the construction of a hospital at Louisville and La Grange Rd. Estimated cost $1,000,000. M. J. Murphy, 1020 Bardstown Rd., Louisville, is architect.

Ky., Paducah—G. C. Sauerbaum, Charleston Apartments, awarded contract for the construction of a 4 story hotel at 22nd St. and Broadway to W. H. Nelson Cundiff Co., 410 North Euclid Ave., St. Louis, Mo. Estimated cost $700,000. Steam heating, refrigeration and ventilation systems, boilers, elevators, etc. will be installed.

Me., Portland—Finks Bros., plan the construction of a 13 story hotel including electric refrigeration system, etc. on High St. Estimated cost $2,000,000.

Me., Sanford—H. D. Goodall Hospital Inc., awarded contract for the construction of a hospital, nurses' home, power house, etc. at Sherburne's Heights to J. W. Bishop Co., 683 Atlantic Ave., Boston, Mass.

Mass., Boston—Hospital Dept., will readvertise for bids for the construction of addition to boiler house and heating plant on Albany St. Former bids rejected.

Mass., Roxbury (Boston P. O.)—Bigelow & Wadsworth, 120 Tremont St., Boston, Archts., are receiving bids for the construction of an electric sub-station on Humboldt Ave. here for Edison Electric Illuminating Co., 39 Boylston St., Boston.

Mich., Detroit—Y. M. C. A., A. G. Studer, Adams Ave., awarded contract for the construction of a 5 story club building at Jefferson and Garland Aves. to Talbot & Meier, 250 West Lafayette Blvd. Estimated cost $500,000. Steam heating and ventilation systems, boilers, elevators, etc. will be installed.

Minn., St. Joseph—Hotel Whitcomb, awarded contract for the construction of a 9 story hotel at Lake Blvd. and Ship St. to M. M. Stock Construction Co. Estimated cost $600,000.

Mo., Cape Girardeau—Missouri Utilities Co., 400 Broadway, is having preliminary plans prepared for waterworks improvements including pumping and filtration plants, etc. at Cape Rock. Estimated cost $176,500. Private plans.

Mo., Macon—City plans an election June 3, to vote $165,500 bonds for waterworks improvements including impounding reservoir, pumping station, earth and rip rap dam, mains, etc. Burns & McDonnell Engineering Co., 402 Interstate Bldg., Kansas City, Mo., are engineers.

Mo., St. Louis—Phillip Rollhaus, Jr., Central National Bldg., Archt., is having preliminary plans prepared for the construction of a 5 story hotel including steam heating system, etc. Estimated cost $750,000. Owner's name withheld.

Neb., Lincoln—State, A. McMullen, Governor, plans the construction of third unit to state hospital building. Estimated cost $2,000,000. R. L. Cochran, is State engineer.

Neb., Omaha—G. Liggett, 1513 Jones St., plans the construction of a 10 story office building. Estimated cost $1,000,000.

N. J., Atlantic City — E. Schwehm, awarded contract for the construction of an 8 story office and stores building at Atlantic and New York Aves. to M. C. Tredennick Co., 25 West 45th St., New York, N. Y. Estimated cost $500,000. Steam heating system, boilers, elevators, etc. will be installed.

N. J., Elizabeth—Elizabeth Chamber of Commerce Hotel Co., 227 Broad St., will soon award contract for the construction of a 9 story hotel and stores building including steam heating, refrigeration and ventilation systems, boilers, pumps, elevators, etc. at 323 North Broad St. Estimated cost $1,000,000. W. L. Stoddart, 50 East 41st St., New York, N. Y., is architect. H. B. Brady, 333 North Broad St., Elizabeth, N. J., is associate architect.

N. Y., New York—Bainbridge Associates, Rochambeau Ave. and 206th St., will build a 6 story apartment. Estimated cost $800,000. G. G. Miller, 1482 Broadway, is architect. Work will be done by separate contracts. Steam heating system, etc. will be installed.

N. Y., New York—J. A. Moller, Inc., 51 East 42nd St., will build a 16 story hotel at 148-152 East 39th St. Estimated cost $650,000. H. I. Cobb, Jr., 51 East 42nd St., is architect. Work will be done by separate contracts under the owner's supervision. Steam heating system will be installed.

N. Y., New York—Walton Manhattan Corp., 250 West 57th St., will build two 6 story apartment buildings at 181st St. from Pinehurst to Northern Aves. Estimated total cost $600,000. Lang & Rosenberg, 1440 Broadway, are architects. Work will be done by separate contracts. Steam heating system, etc. will be installed.

O., Apple Creek—Dept. of Welfare, J. E. Harper, Dir., Oak and Ninth Sts., Columbus, is having sketches made for the construction of a new institution for Feeble Minded including power and sewage disposal plants, etc. here. Estimated cost $650,000. H. B. Briggs, Ohio-Hartman Bldg., Columbus, is architect.

Okla., Kaw City—T. C. Hughes, 1626 South Baltimore St., Tulsa, E. G. Pike, 905 South Elwood, St., Tulsa, & Associates, are having preliminary plans prepared for the construction of a power plant on the Arkansas River between Kaw City and Fairfax. Estimated cost $200,000. Private plans.

Pa., Pittsburgh—Duquesne Light Co., 431 6th Ave., will build a sub-station on West Liberty Ave. Estimated cost $40,000. Private plans. Work will be done by separate contracts.

Pa., Pittsburgh—Rodgers Sand Co., 1 Wood St., will soon award contract for the construction of a sand and gravel plant including boiler house, etc. on Ridge Ave. Estimated cost $250,000. Hunting Davis Co., Century Bldg., are architects.

Texas—Kansas—Cities Service Co., 60 Wall St., New York, N. Y., awarded contract for the construction of a natural gas pipe line, 250 mi. from Panhandle, Tex. to Wichita, Kan. including three 9000 hp. compressor stations, etc. to Booth & Flinn Ltd, 1942 Forbes St., Pittsburgh, Pa.

Tex., Beaumont—E. G. Edson c/o Edson Realty Co., is having preliminary plans prepared for the construction of a 14 story hotel including steam heating, refrigeration and ventilation systems, boilers, elevators etc. at Pearl and Liberty Sts. Estimated cost $1,500,000. F. W. Steinman & Son, 411 San Jacinto Life Bldg., are architects.

Tex., Laredo—S. N. Johnson, plans the construction of a dam on the San Ildefonso Creek to impound water to irrigate 988 acres of land, will probably include gravity and pump systems. Estimated cost including machinery $40,000. Private plans.

Tex., Laredo—L. L. Stephenson, 205 East Mulberry St., San Antonio, and M. Little, Laredo, awarded contract for the construction of a 12 story hotel annex to C. M. Schoenfeld, Laredo. Owner will receive sub-bids later on steam heating, refrigeration and ventilation systems, boilers, elevators, etc.

Tex., Marble Falls—Syndicate Power Co., has been granted permit to construct a power dam, 1200 ft. long and 40 ft. high on the Colorado River, south of Kingsland. Estimated cost $250,000. W. S. Arnold, c/o owner, is engineer.

Tex., Port Arthur—N. M. Barrier, Port Arthur, and J. Hani, Beaumont, plan the construction of a 10 story hotel including steam heating, refrigeration and ventilation systems, boilers, elevators, etc. here. Estimated cost $500,000.

Tex., Waco—Hilton Hotel Co., c/o C. N. Hilton, Dallas, is having plans prepared for the construction of a 12 story hotel at 5th and Franklin Sts. here. Estimated cost $500,000. Lang & Witchell, 300 American Exchange Bank Bldg., Dallas, are architects.

Ont., Ottawa—Dept. of Public Works, plans the construction of a 10 story office building on Wellington St. Estimated cost $3,000,000. T. W. Fuller, c/o Dept. of Public Works, is architect.

Ont., Thistletown—Hospital for Sick Children, College St., Toronto, awarded contract for the construction of a hospital including power plant on Weston Rd. here, to Jackson Lewis Construction Co., Federal Bldg., Toronto. Estimated cost $500,000.

Ont., Toronto—H. Falk, 63 Alvin Ave., awarded contract for the construction of a 5 story apartment building at Clarendon Ave. and Avenue Rd. to John V. Gray Construction Co., Ltd., 541 Queen St. Estimated cost $850,000. Steam heating system, elevators, etc. will be installed.

Ont., Toronto—Loblaw Groceterias Ltd, 1385 Bloor St. W., will receive bids about May 28 for the construction of a warehouse including steam heating system, elevators, etc. at Fleet St. and Spadina Ave. Estimated cost $500,000. W. F. Sparling Co., Metropolitan Bldg., is architect.

Ont., Toronto—F. R. Pember, 325 Jones Ave., awarded contract for the construction of coal pockets and storage bins. Estimated cost $25,000. Electrically operated conveying equipment will be installed.

Ont., Toronto—Toronto Electric Comrs., 225 Yonge St., awarded contract for the construction of an electric sub-station including 1000 kva. transformers, etc. to The Avery Shipp Construction Co., 2850 Dundas St. W. Estimated cost $150,000.

Ont., Windsor—Deauville Beach Club, 630 Book Bldg., Detroit, Mich., had plans prepared for the construction of a 9 story club building including steam heating and refrigeration systems, boilers, elevators, etc. here. Estimated cost $1,000,000. F. D. Madison, 212 First State Bank, Royal Oak, Mich., is architect.

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Equipment Wanted

Air Compressor and Pumping Units—Bd. of Trustees, O. D. Frost, Chn., South Orange, N. J., will receive bids until June 17 for furnishing and installing two complete motor driven air compressor and water pumping units in pumping station at Water Lands.

Air Compressor, Switchboard, Etc.—Division of Architects and Engineers, Capitol, Springfield, Ill., will receive bids until June 21 for an air compressor, switchboard, coal conveyor, etc. in power house for Illinois State Penitentary at Stateville, Ill.

Boiler—Treasury Dept., office of J. A. Wetmore, Acting Supervising Archt., Washington, D. C., will receive bids until June 16 for furnishing and installing a boiler and connections in U. S. Post Office at Washington, Pa.

Boilers & Accessories—Indiana State Normal School, Indiana, Pa., will receive bids until June 2 for furnishing and installing boilers, stokers, combustion control, coal conveying machinery, pumps, etc. for new power house.

Engine—A. Miller, Trail, O., is in the market for an oil engine for power plant.

Engines—Gregory Gin Co., Halifax, N. C., is in the market for 75 to 100 hp. oil engines.

Heating System—Bureau of Yards & Docks, Navy Dept., Washington, D. C., plans the installation of a steam heating system including fire box boilers, fuel oil pumps, boiler feed and vacuum pumps, motors, etc. at Naval Operating Base (Air Station) San Diego, Calif.

Pump and Motor—La Mesa, Lemon Grove and Spring Valley Irrigation Dist., La Mesa, Calif., will receive bids until June 7 for furnishing and installing a centrifugal booster pump and motor, etc.

Pumping Equipment—City of Lampasas, Tex., will be in the market for pumping equipment for proposed waterworks improvements. Estimated cost $30,000.

Pumping Equipment—City of Turkey, Tex., will be in the market for pumping equipment for proposed waterworks system. Estimated cost $45,000.

Pumping Equipment, Etc.—City of Ogden, Ia., will be in the market for pumping equipment, etc. for proposed waterworks improvements. Estimated cost $15,000.

Pumping Equipment, Etc.—City of Cassville, Mo., will be in the market for pumping equipment, etc. for proposed waterworks improvements. Estimated cost $25,000.

Pumping Equipment, Motors, Switchboards, Etc.—City of Galesburg, Ill., will receive bids until June 27 for furnishing and installing pumping equipment, motors, switchboards, etc. in proposed new pumping station.

Pumps—City of Dorchester, Neb., will be in the market for pumps, etc. for proposed sewage disposal plant and pumping station. Estimated cost $35,000.

Pumps, Etc.—City of Ironton, Mo., will be in the market for pumps, etc. for proposed improvements to waterworks.

Pumps, Etc.—City of Hillsdale, Okla., will be in the market for pumps, etc. for proposed improvements to waterworks and distribution systems. Estimated cost $15,000.

Pumps and Motors—City of Tahlequah, Okla., will be in the market for two triplex pumps and motors for proposed water supply of Duffing Springs. Estimated cost $40,000.

Pump and Motor—City of Wynnewood, Okla., is in the market for a 150 g.p.m. triplex pump and 15 hp. motor.

Refrigeration Equipment—Bureau of Yards & Docks, Navy Dept., Washington, D. C., plans the installation of automatic refrigeration unit consisting of motor driven compressor, condenser and accessory equipment for proposed cold storage plant at Naval Air Station, Lakehurst, N. J.

Refrigeration Equipment, Cold Storage Doors, Etc.—Merchants' Refrigerating Co., 41 River St., Newark, N. J., is receiving bids for refrigeration equipment, cold storage doors, etc. for proposed 9 story cold storage and refrigeration plant.

Turbo-Alternator, Ash Handling System, Etc.—Bureau of Yards & Docks, Navy Dept., Washingtno, D. C., will receive bids until June 15 for a 625 kva. turbo-alternator, also until June 22 for ash handling system, etc. at Marine Barracks, Paris Island, S. C.